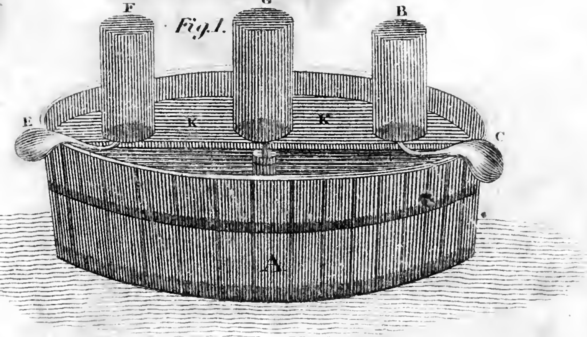
Geo. F. Dow
1884.

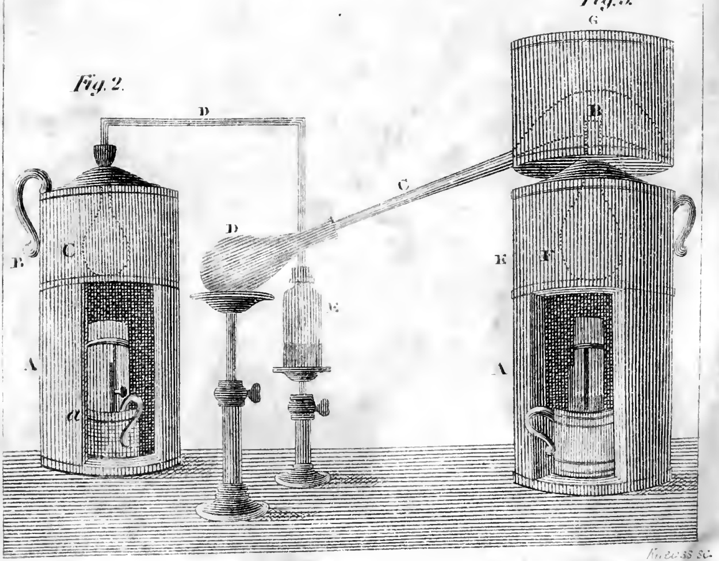
Pneumatic Tub

Fig. 1.



Economical Apparatus of Dr. Woodhouse

Fig. 2. Fig. 3.



A GRAMMAR OF CHEMISTRY,

WHEREIN

THE PRINCIPLES OF THE SCIENCE ARE FAMILIARIZED BY A VARIETY OF EASY AND ENTERTAINING

EXPERIMENTS;

WITH QUESTIONS FOR EXERCISE,

AND

A GLOSSARY OF TERMS IN COMMON USE.

BY THE REV. D. BLAIR.
AUTHOR OF THE GRAMMAR OF PHILOSOPHY, &c. &c.

CORRECTED AND REVISED BY
BENJAMIN TUCKER,
Author of Sacred and Profane History epitomized, &c.

THIRD EDITION,
Improved, and adapted to the present state of the science. Intended as an Elementary Book for Schools, and a Companion for private Students, particularly those who wish to attend popular Lectures.

PHILADELPHIA:
PUBLISHED AND SOLD BY DAVID HOGAN,
No. 249, Market street.

....

1819.

District of Pennsylvania, to wit:

L. S.

BE IT REMEMBERED, That on the thirteenth day of October, in the thirty-fifth year of the Independence of the United States of America, A. D. 1810, DAVID HOGAN, of the said District, has deposited in this Office, the Title of a Book, the right whereof he claims as Proprietor, in the words following, to wit:

"A Grammar of Chemistry, wherein the principles of the Science "are familiarized by a variety of easy and entertaining Experiments; "with Questions for exercise, and a Glossary of terms in common use. "By the Rev. D. Blair, author of the Grammar of Philosophy, &c. "Corrected and revised by Benjamin Tucker, author of Sacred and "Profane History epitomized, &c Intended as an Elementary Book "for Schools, and a Companion for private Students, particularly "those who wish to attend popular Lectures."

In conformity to the Act of the Congress of the United States, intituled, "An Act for the encouragement of learning, by securing the Copies of Maps, Charts and Books, to the Authors and Proprietors of of such Copies, during the times therein mentioned;" And also to the Act, entituled "An act supplementary to an Act, entituled, 'An act for the encouragement of learning, by securing the Copies of Maps, Charts, and Books, to the Authors and Proprietors of such Copies, during the times therein mentioned,' and extending the Benefits thereof to the arts of designing, engraving, and etching Historical and other Prints."

D. CALDWELL,
Clerk of the District of Pennsylvania.

PREFACE

TO THE AMERICAN EDITION.

THE science of Chemistry has become so popular and fashionable a study, that to be wholly unacquainted with it, rather betrays a mortifying ignorance. It seems therefore highly proper, that its elementary principles should be brought into so narrow a compass, as to enable every person to become acquainted with the general outlines of the Science, without intruding too much upon other avocations. And, in our Seminaries where a liberal English education is taught, it is surely high time to add this interesting and useful study.

Under the influence of this impression, and also with a view to furnish a text book for such as wish to attend popular lectures on Chemistry, the following little work has been revised: The corrections and additions which have been made, are principally such, as could not with propriety be dispensed with.

Although the general plan of the work, and the brevity studied by the author throughout the compilation, rendered it a most valuable elementary book, yet opinions had been occasionally advanced which were opposed to experiment. In the production of hydrogen gas by a union of iron with water and sulphuric acid, the author differs from late writers on that subject, by asserting that the acid as well as the water is decomposed—In the formation of writing ink, he says, the green

sulphate, instead of the red, unites to the gallic acid, to form a gallate of iron, or common ink— The ashes of sea weeds, instead of the saline matter extracted from them, he calls kelp: With several other errors of a similar kind, which, although they were not of great magnitude, yet, *as they were errors*, it was necessary they should be corrected.

From the support which has been lately given to the opinion, that heat is a property of matter, by Professor Davy, of the Royal Institution of Great-Britain, and by Dr. Young, late Professor of Natural Philosophy in the same Institution, I thought the insertion of that theory, as well as the more generally received one, might not be improper—I have therefore added it.

I have also added a description of Chrome, a metal which has been found in combination with iron, in great abundance in the neighbourhood of *Baltimore*; and which, if it can be separated by a cheap process from the iron with which it is combined, will be found to furnish, in its combinations with the metallic oxides, the most beautiful and durable paints.

In attending a first course of Lectures on Chemistry, new terms, however well defined by the Lecturer, will be but very imperfectly remembered; and when they are repeated by him without explanation, will very probably be wholly unintelligible. Thus it frequently happens, that the loss of a few words, which if well understood, would have thrown light upon the subject, and given us a high interest in it, by being unintelligible, spoils the lecture, and creates dissatisfaction. In order to remove in some measure this inconve-

nience, I have added to the glossary a number of terms which had been omitted by the author: So that if a difficulty should occur, by turning to the glossary while the Lecturer is speaking, it may immediately be removed.

B. TUCKER.

ADVERTISEMENT

TO THE SECOND EDITION.

A NEW Edition of the GRAMMAR OF CHEMISTRY becoming necessary, in consequence of a large impression having been disposed of, I have embraced the opportunity for giving the work a careful revisal. In doing this, I have made such corrections as the advancement in Chemical science rendered necessary. I have also added several important facts: amongst which may be particularly noticed, Professor DAVY's interesting discovery of the means for *preventing the disastrous effects of fire damp in mines*; and SINGERS' curious invention of a *perpetuated motion*, without the aid of a mechanical force.

It is unnecessary to enter into a detail of the merits of a work which has been several years before the public. It may, however, with safety be said, that few, if any, of equal size contain more useful information on the subject of which it treats.

B. TUCKER.

Philadelphia, January, 1817.

NOTICE

TO THE PRESENT EDITION.

Another edition of this little work being called for, I have again given it a careful review; and have made such corrections as appeared in any wise to be necessary. I have also judged it expedient to give a more full and satisfactory explanation of the different species of *attraction*, as well as of simple and compound *affinity*. The several doctrines which mark the *present era of chemical science* have likewise been fully noted; and, in order that the young student may not too implicitly receive new theories, when these doctrines are doubtful, I have offered such objections as are sanctioned by Chemists of acknowledged eminence.

B. TUCKER.

Philad. May, 1819.

EXPLANATION OF THE PLATE.

Fig. 1. A is a pneumatic tub. K, K, a shelf on which the inverted glass jars B, G, F, are placed. C and E are glass retorts. (See also page 32.)

Fig. 2. A is a cylindrical vessel of tin, thirteen inches high, and twenty-one in circumference, open at *a*, so as to admit a lamp, with a round aperture in the top, three inches in diameter. B is a circular case, four inches high, formed of two pieces of the same metal, which include a column of atmospheric air, one inch thick, at the top and on the sides. The lower part has an opening five inches in diameter, and in the middle of the upper part, there is an aperture to receive the neck of an oil flask. C is a flask from which proceeds the tube D, which enters the bottle E.

In using this apparatus, the flask, containing the subject of the operation must be placed on the cylindrical body A. The case B is then to be put over the flask, and the tube D, which enters a perforated cork, luted to it with a strip of paper, covered with a paste made of flour and water. The atmospheric air which the case B contains, is a bad conductor of heat; hence upon applying an Argand lamp to the bottom of the flask, the heat is accumulated round its sides, and thus prevented from flying off into the air.

Fig. 3. A is the cylindrical vessel of tin, E the case containing the atmospheric air, and F an oil flask, on the neck of which, the head of an alembic B, made of tin or copper, seven inches high, is placed; C the head of this vessel, thirteen inches long, enters an oil flask D.

To use this apparatus, the flask must be placed on the top of the cylindrical body A. The vessel containing the atmospheric air, is then to be placed over the flask, and the head of the alembic fixed to its neck, G, the part over the top of the head of the alembic must be filled with cold water.

INDEX.

A

GRAMMAR

OF

CHEMISTRY.*

GENERAL PRINCIPLES.

1. THE object of chemistry is to ascertain the ingredients of which substances are composed, to examine the nature of those ingredients, and the properties resulting from their combination or union.

2. Substance, or body, denotes any existing matter, whether solid or fluid.

* This science, says W. Henry, unfolds sublime views of the beauty and harmony of the universe, and developes a plan of vast extent and uninterrupted order, only conceivable by perfect wisdom, and executed by unbounded power. By withdrawing the mind also from pursuits and amusements which excite the imagination, its investigations may tend to the improvement of our intellectual and moral habits, to strengthen the faculty of patient and accurate thinking, and to substitute placid trains of feeling, for those which are too apt to be weakened by the contending interest of man in society, or the imperfect government of our own passions.

Illustration. A stone is a solid body: water and air are fluid bodies.

3. All substances subjected to chemical investigation, are considered either as simple or compound.

4. Simple bodies are those which cannot be separated into others more simple; and compound bodies are those which are compounded or composed of simple bodies.

Illustration 1. When we set fire to a piece of wood or coal, light and heat are emitted, and the solid matter of the wood is converted into water, a kind of air, and several other new products. Hence it is evident that wood and coal are compound bodies.

2. Lead is a simple body, but common red lead, used by painters, is compounded of lead and a certain part of the atmospheric air, and these may be separated from one another by a proper degree of heat. Thus the air will be driven off in the form of gas, or vapour, and the lead will remain in its original state.

5. Man cannot create or annihilate any particle of matter; but by the aid of chemistry he can render obvious to sense, that which was latent or hidden.

Illustration. In the burning of a candle, both light and the matter of heat are furnished, but the chemist can prove that it is not the candle altogether which yields these materials, but, in a great measure, the surrounding atmosphere, and not the whole of that atmosphere, but one of its constituent portions. All the changes presented in the different kingdoms of nature, are considerably connected with the great agents, water and air, aided by light and warmth, or the energy of the matter of heat.

6. The physical properties of matter are distinguished from the chemical.

Illustration. Thus, lead has divisibility, impenetrability, *vis inertiæ*, extension, weight, attraction, &c. not as lead, but as matter, for all natural bodies have the same characters; but it is not the property of any body in nature, (lead excepted) by a union with another simple substance, to produce minium, or red lead.—This, therefore, is an *individual* property of the lead, and *all individual properties are chemical.*

7. The liquid by which any solid is dissolved, is called the solvent, or menstruum.

8. Solution is promoted by mechanical division, by heat and by agitation.

9. A mere mechanical mixture is different from a chemical solution. Mixtures are always turbid or opaque. Solutions are transparent.

Illustration 1 A stone or an earth my be reduced to a powder, and mixed with water, but the solid particles will gradually sink to the bottom This is a mixture.

2. When a lump of camphor is put into a glass of alcohol, the camphor dissolves, and the fluid retains its transparency; the alcohol and camphor being blended together by a mutual attraction. This is a solution.

10. There is a certain limited quantity which fluids will dissolve or take up by the power of attraction; whatever part of the solid body exceeds this limit, will fall to the bottom undissolved.

11. This point or limit is called the point of *saturation.*

Illustration 1. If we gradually drop salt into a glass of water, saturation is said to have taken place when the salt begins to fall to the bottom, instead of being dissolved in the liquid. If the solution be drained off from these particles of salt, it is then called a saturated solution.

2. There is also a point or limit in certain cases, beyond that of saturation. It is termed super-saturation, of which we have an instance in steel and plumbago. Both of these are compounds of iron and carbon. Black-lead, which contains not an atom of lead, is iron saturated in the second degree with carbon. Steel, on the other hand, is iron united to the first point of saturation with the same principle, carbon.

12. All the phenomena of chemistry arise from the attractions and repulsions exerted between the particles of matter.

13. The term *attraction* is employed to denote the power or force, by which bodies have a tendency to approach to each other, to enter into more or less intimate contact or union, and to remain in that state.

14. Different species of this force have been observed, which give rise to different effects, and operate according to different laws. A general distinction may be stated between them, according as they operate at greater or less distances: and according as they affect the masses or particles of matter.

15. Attraction of gravitation, the most general in its agency, is exerted between the largest masses of matter, placed at sensible and often at immense distances.

Illustration. A stone, unsupported in the air, falls to the ground by the attraction of gravitation.

16. Attraction of cohesion, or aggregation, is exerted only between particles of the same kind of matter. It unites them so as to form a mass or aggregate, the hardness

of which is proportioned to the force with which this attraction is exerted. But the properties of the mass are always the same with those of the particles which compose it.

Illustration. Hardness, softness, brittleness, ductility, and maleability, all depend upon different modifications of this attraction of cohesion.

17. When the attraction of cohesion is exerted suddenly, the particles unite indiscriminately, and form irregular masses. But when it resumes its force more slowly, the particles assume a particular arrangement, and form masses of regular figures. This is termed *chrystallization*, and the regular figured masses are denominated *crystals*.

Observation. While gravitation is the source of all the sensible motions of the Universe, contiguous attraction gives origin to many important phenomena arising from the insensible motions of the particles of matter.—Exerted between bodies of the same kind, it is the cause of the different forms in which they exist, and the regular figures which many of them are capable of assuming: Exerted between particles of a different kind, it is the source of all the combinations of matter which constitute so important a part of the economy of nature.

18. Chemical attraction, or, as it is more generally termed, *chemical affinity*, is exerted between the particles of different kinds of matter; and when it unites them, forms substances, which have qualities different from those of the bodies that have been combined.

Observation. This law of attraction is of the highest

importance. It is from it that the properties of the greatest number of material bodies are derived.—Almost the whole of the productions of nature are compounds, formed from the union of a few simple substances: and the numerous properties which they possess, adapting them to so many purposes of utility, are derived from this source.

19. When particles of different kinds, form a new substance, this is called composition, or *synthesis:* and when these are again separated from their union, it is termed decomposition, or *analysis.*

Illustration 1. An instance of composition or synthesis is seen, when muriatic acid is added to lime. The two substances unite and form what is termed a muriate of lime.

2 Decomposition or analysis is instanced, by adding an alkali to this muriate of time; in consequence of which the lime will be separated from the muriatic acid, and will fall to the bottom of the vessel.

3. Analysis is of two kinds, simple or destructive.—The instance given refers to simple analysis alone; for when the muriatic acid is disengaged from the alkali by the sulphuric, the same quantity of lime at first obtained can be re-combined with it, and thus the original compound muriate of lime regenerated. But if a flower were treated chemically, we should obtain from its analysis various different substances, but we should in vain endeavour to re-produce by any new combination of these products, the primitive fragrance of the flower. Hence destructive analysis.

20. When the decomposition of a body is effected by a single new substance, this is termed simple affinity: But when it requires a body which is itself composed of two or more principles, which could not each sepa-

rately perform the decomposition, it is termed compound affinity.

Illustration. If sulphuric acid be added to a solution of the acetate of lead, the sulphuric acid will combine with the lead and will be precipitated, while the acetic acid will be set at liberty.—This is an instance of simple affinity. But if a solution of the sulphate of soda be added to the acetate of lead, the sulphuric acid will combine with the lead, and the acetic acid with the soda, and will, by the decomposition of the two former substances, form two new compounds.—This is termed compound affinity.

21. Besides the species of attraction already described, there is electric and magnetic attraction.

Illustration. When amber or sealing-wax are rubbed, they attract feathers, or other light bodies. This is *electric attraction.* The force by which the needle is determined to the pole is termed *magnetic attraction.*

OF SIMPLE SUBSTANCES.

22. Simple substances are such bodies as the power of chemistry have hitherto been unable to decompose.

Observation. The number of simple substances is constantly changing. Experiment has discovered, that several held as such, are composed of two or more of the rest.

23. Among the simple bodies are,
LIGHT—CALORIC, or the matter of heat;
OXYGEN, or the acidifying principle;
HYDROGEN, or the basis of water;
CARBON, or DIAMOND; and the
METALS.

24. NITROGEN, PHOSPHORUS, SULPHUR, the EARTHS, and ALKALIES, cannot properly be reckoned as simple bodies.

OF LIGHT—CALORIC.

25. There are two opinions concerning the nature of caloric, which have long divided philosophers, and which are still prevalent.

26. The first, that it is a distinct, but very subtile fluid, which pervades the pores of all bodies.

27. The second, that caloric consists in a minute vibratory motion of the particles of bodies; and that this motion is communicated through an apparent vacuum by the undulations of an elastic medium, which is diffused through the pores of different ponderable substances, and which is also concerned in the phenomena of light.

28. Light, according to the first of these opinions, is considered as a distinct substance, consisting of exceedingly small particles, which are projected with inconceivable velocity from luminous bodies.

29. According to the second opinion, light arises from the vibrations propagated through an elastic medium, which is diffused through all space, and in which luminous bodies have the power of exciting these vibrations, in the

same manner that sonorous ones produce vibratory motions in the air.

30. The difference betwcen light and heat, according to the second opinion, arises from the undulations constituting heat, being larger and stronger than those of light. The first of these opinions with respect to light and heat is the most general.

31. Animal heat is that principle or power by which the body is kept warm, and by which living beings are enabled to communicate warmth to surrounding bodies.

32. Caloric is produced by the discharge of an electric battery, or by the galvanic apparatus; from the latter of which a more intense degree of heat may be obtained than by any other means whatever.

Observation. An ingenious invention of perpetual motion, in the ringing of bells, produced by an electric column, which was discovered by Deluc, and improved by Singers, has excited considerable attention. The electric column, consists of several hundred small discs of zink, and equal pieces of plain gilt Dutch paper, (which is paper covered with copper,) about seven tenths of an inch diameter These are placed upon each other alternately, and enclosed in a glass tube. The upper side of the gilt paper being turned to one end of the tube, becomes the positive extremity of the column; and since the paper seems only to separate the binary groups of zink and copper, the latter being in each of them on the other end of the tube, this becomes the negative extremity of the column. When the number of discs amount to 800 or 1000, the apparatus will at any time produce a perceptible effect upon the electrometer, without any preparation.

Singers constructed an apparatus with two of these electric columns, which never ceased to ring for 14 months, except during its removal from one place to another. The columns were placed vertically, and enclosed in a glass receiver, having a bell fixed at the lower extremity of each, and a brass ball suspended between them by a fine thread of raw silk. This ball, from the attraction and repulsion excited by the electricity of the columns, is kept in motion, so as to produce a perceptible sound from the bells. In Singers' description of his electric columns he says, "There appears every reason to believe that the action of a well constructed column will be permanent. I have several that have been constructed nearly three years, and they are still as active as at first."

33. Caloric, in the act of passing from one body to another, becomes perceptible to the senses.

34. Caloric expands bodies in all directions. It is conspicuously diffused throughout nature.

Illustration 1. Though it be the cause of liquidity and the gaseous state, still bodies in a concrete form contain much of this matter uncombined. This is known by such processes as lower the temperature of different bodies. So long as any substance can be cooled, so long it has the power of parting with heat, and we have yet to learn the point at which we could assert that it has parted with all it contains.

2. When caloric is extracted from steam, it becomes water, and when from water caloric is abstracted, ice is produced.

3. Bodies which exhibit properties arising from increase or diminution of caloric, are said to be of a certain *temperature*. And as it is probable that no substance can have its temperature reduced to 0, in the scale of heat, so it must follow that the particles of solid bodies are never in actual contact.

Example. Thermometers and pyrometers are instruments for measuring the relative degrees of heat by the expansion of liquids or solids. The degrees of expansion are determined by reference to a suitable scale.

35. As heat is necessary to the fusion of ice, or any other solid body, the same substance is evolved during the act of congelation. Warmth is therefore presented to surrounding bodies during the natural operation of freezing.

36. The same quantity of caloric which keeps some substances in an æriform state, presents liquidity and solidity only, in others.

37. Caloric cannot be accumulated in any body beyond a certain extent.

38. The tendency which heat has to flow from solids into surrounding bodies, when the former are raised to a certain temperature is well known.

Illustration. A ball of iron, (being made red-hot) soon looses its temperature, and becomes of the same degree of heat as the surrounding bodies.

39. Caloric has been enumerated by some under the head of imponderable substances, because the nicest experiments have not proved it to be possessed of weight.

40. Caloric is conducted through different bodies with more or less facility.

Illustration 1. When rods of iron, porcelain, and wood, of equal lengths and diameter, are exposed to the fire, the ends at a distance will convey the heat very differently; the iron will become very hot, whilst the porcelain and wood will scarcely be heated at all.

2. A purse containing money, when held to the fire, scarcely becomes warm, while the money becomes so hot as not to be touched. Hence the falicity with which bodies are heated or cooled, is proportioned to their conducting power.

3. Ice, wrapped in wool, fleecy-hosiery, down, or fine dry charcoal powder, takes a very considerable time before it thaws in an atmosphere of considerably higher temperature.

4. Expansion and contraction is a serious inconvenience on several occasions. In instruments for measuring time, it is particularly so. Musical instruments should not have strings of different metals, for by any change of temperature in the atmosphere, they are apt to go out of tune.

5. Brittle bodies, such as glass, are but bad conductors of heat; hence, the surface to which heat is suddenly applied by inordinate expansion, generally produces fracture. It is on this account that capsules, Florence flasks, and retorts of glass, to be used over lamps, or at the naked fire, should be as thin as possible, provided they be of sufficient strength to bear their contents.

41. Fluids have the property of carrying or transporting caloric; in consequence of which they acquire heat much more rapidly than solids, independent of any conducting power.

Illustration. Fluids necessarily contain more latent heat than solids, but as the capacity of bodies for caloric is increased, their conducting power seems to be diminished, as in the case of liquids and gases, which appear to be such bad conductors of heat, that *Rumford* supposed this power was only communicated by interchange of heated particles.

Experiment 1. Hot water, on the surface of cold water, in a tube, remains long nearly at the same temperature, whereas, when disposed at the bottom, the reverse occurs.

2. When a vessel of cold water is placed over a fire, the heat expands, and therefore renders the water of less specific gravity at the bottom of the vessel, which portion of water ascends to the top, while another of equal volume being colder, and consequently heavier, bulk for bulk, falls to the bottom, and in this way there is a constant circulation from the under to the upper part of the vessel.

3. Ice is readily melted when placed at the surface of a vessel of hot water, but it requires at the bottom eighty times the length of time to fuse it, showing with what difficulty heat is communicated downwards, or by radiation in liquids.

42. Water swells upon being frozen, from two causes: First, from the extrication of the portion of air which it holds in solution, and which freezing disengages. This air forms those numerous cavities that are found in ice. Second, from the frozen particles of water assuming a different arrangement, and therefore requiring more room.

Elucidation. From this cause it is, that in severe frosts the aqueous fluids of plants, on sudden concretion, split even the knotted oak, with incalculable force, accompanied by powerful explosion.

Experiment 1. When water is poured over a block of Irish slate, set on edge, (over night) it is found to be readily split into layers by the freezing of the water within its different *leaves*.

2. A bottle filled with water, and corked on freezing, never fails to be broken.

43. Deep lakes of water do not freeze in winter.

Illustration. This is owing to the circumstance of colder air being constantly presented at the surface of the lake, which causes a portion of the water to lose its tem-

perature, and thus becoming heavier, falls gradually to the bottom, while the warmer water below ascends, forming a new surface in its place. Hence the beautiful commerce between the ocean and the atmosphere, the former of which containing against winter, the season of need, such hoards of warmth as to supply the incumbent atmosphere, which again repays in warmer seasons the loan. Hence the more equable temperature of insular situations, when compared with places of the same latitude, far from the sea.

44. The chemical effects of caloric in melting or fusing metals, earths, and other solid bodies, are equally striking with its effects in expanding or heating fluids.

45. Expansion differs from fluidity.

Illustration. For no substance can be expanded beyond a certain limit, during which time its specific gravity diminishes, or a given volume weighs less, and its temperature increases, as may be distinguished by the sense of feeling.

Experiment. Expose ice and ice-cold water, to the same degree of heat, the ice will not become hotter, but the water will. When, however, the ice is entirely fused, it will increase in its temperature, as the ice-cold water does.

46. In bodies which expand, there is a regular increase and contraction of bulk, according to the degree of heat.

47. All solids, (which are not decomposed by caloric alone) fuse at a determinate point, which is termed their melting point. No two substances fuse at the same temperature.

Illustration. Tallow melts in the hand, but the highest degrees of heat, capable of being excited in our furnaces, do not, (properly speaking) liquify platina. It is, however, fusible.

48. It requires a certain temperature to maintain all bodies liquid. Many are solid at that of the atmosphere.

Illustration. These solids, when fused by excess of heat in furnaces or otherwise, gradually concrete on being exposed anew to the ordinary temperature.

49. Some bodies, such as earths, stones, &c. concrete or melt into masses like glass. This operation is called vitrification. But the reducing metals from a solid to a fluid, by the application of heat, is termed fusion.

50. Another important effect produced by caloric, is the formation of vapour or steam.

51. By vapour is meant a transparent fluid like air, of great elasticity, and capable of being greatly increased in bulk by additions of heat.

Illustration 1. This effect of the immense force of vapour is exemplified by the small pieces of glass called candle balls, sold in the toy-shops. These glass balls when fixed near the flame of a lighted candle, burst with a loud noise from the expansion into vapour of the drop of water they contain.

2. Great danger attends the melting of metals, or boiling of oils, in consequence of the expansive power of vapour; for, if by any accident, a small quantity of water falls into the vessel containing the hot fluid, it will be converted into vapour with such rapidity, as to scatter the fluid, metal, or boiling oil, in all directions, with an explosion resembling that of gunpowder.

52. The point at which a fluid is converted into vapour, depends upon a certain degree of heat called the boiling point. The boiling point of water has been fixed at 212°

of Fahrenheit's thermometer, and the freezing point at 32°.

53. If water can be prevented from going off in steam, as it may by means of a particular contrivance, it will acquire a degree of heat equal to that of metals when red hot.

Illustration. The machine used for this purpose is called Papin's digester, and is a copper vessel half filled with water, the head of which is closely screwed down. When the water is so hot as to send off vapour, its escape is prevented by means of a weight and lever across the lid, which confine it in proportion to the increased pressure of the vapour. Lead and tin have been melted in this machine, and bones have been totally dissolved, leaving nothing but earth or ashes.

54. Water does not become hotter by being boiled long in the common way; after being heated to the boiling point, the heat gradually converts a portion of the water into vapour, and the additional heat applied to the water, goes off with the vapour.

55. This last property in steam or vapour of retaining a great quantity of heat or caloric, has suggested the idea of warming houses by means of steam instead of coals or other fuel.

Illustration. There are several large manufactories, besides private houses, both in England and Scotland, warmed in this manner. In the lower part of the building, or in the kitchen, a furnace is erected, to which a large boiler or copper is fixed: from this an iron pipe or tube ascends, and is made to pass through every apartment of the building until it reaches the roof. The heated air or steam passing through these pipes, diffuses an equable

degree of heat throughout the whole of the building, and the saving, in point of fuel, is found to be immense.

56. Heat is also the agent employed in the operations of *evaporation*, *distillation*, and *sublimation*.

Example 1. If we take a mass of clay, water, and quicksilver, and expose it to heat, the water will first rise in a vapour, and be entirely expelled before the quicksilver begins to rise, and this vapour may be condensed into pure water. By increasing the heat, the quicksilver will rise also, and leave the clay by itself. This process is called *evaporation*, that is, when we wish to obtain a fixed and solid substance, and are not anxious about the parts which fly off or are evaporated.

2. When we wish to obtain the volatile parts condensed into a fluid, the process is called *distillation*.

3. When the vapours given off from a body by means of heat condense into a solid form, the process is called *sublimation*, and the produce a *sublimate*.

Experiment. An instance of which is beheld when camphor is exposed to heat over a lamp in a crucible, when a cold body, as a plate of copper or iron is presented, it condenses the vapours, and re-exhibits the invisible odorous fluid again, in a concrete, and often in a chrystalline form.

57. Heat operates in a different manner upon animal and vegetable substances from what it does on minerals.

Example. If a piece of flesh be exposed to heat, it is not, like iron, expanded, but on the contrary, is contracted, from the moist or humid parts flying off.

58. *Combustion*, to which air is an indispensible requisite, is the most important source of caloric. Such bodies as are capable of inducing this effect, are named *combustible bodies*.

59. Bodies which are not combustible, are not altered by heat in a permanent manner.

60. Combustible bodies, on the contrary, by the decomposition of oxygen gas become sources of light and heat. Their capacity of producing light and heat is however gradually exhausted, and what remains after combustion, appears to be a different substance, and no longer combustible.

61. Incombustible bodies readily receive caloric from surrounding bodies of any kind, of a higher temperature, and as readily part with it again when the temperature is diminished.

Observation. This does not apply to organic matter, to animal or vegetable substances, after death, nor even during life, except within a very limited range. When any part of the body is burnt, destructive analysis takes place, and the vital principle is banished from the part.

Experiment 1. When a stone made red hot is plunged into water, the warmth it loses is not extinguished, for it will be found, in proportion to its quantity, to have elevated the temperature of the liquid.

2. Bodies of the same temperature do not communicate or imbibe heat with the same facility. Thus quicksilver appears colder than water, water than oil, lead than marble, marble than wood, though all are, in reality, of the same temperature.

Observation. In these instances, it is plain that the hand more readily parts with its heat to some of these bodies than to others, leaving a lesser or greater impression of cold, as more or less heat is abstracted in equal spaces of time.

OF OXYGEN.

62. Oxygen is never found in an uncombined state. It approaches nearest to purity in the state of a vapour or oxygen gas.

63. Oxygen combines with all the metals, depriving them of their metallic lustre as well as cohesion, and giving them an earthy or rusty appearance. This combination which was formerly known by the name of calx, is now termed an oxide.

64. Some of the metals become oxidized, or are rusted, by mere exposure to the damp and moisture of the common air.

Example. The rust which iron so readily contracts, is an oxide of the metal produced by its attracting the oxygen from air or water.

65. All the metals, at suitable temperatures, become oxidized in contact with the atmospheric air; even gold and silver formerly supposed incapable of corrosion, may, like the other metals, lose their metallic splendour and become oxides.

66. All oxides are heavier than the quantity of the metal which produced them, in proportion to the quantity of oxygen with which they are combined.

67. The mode of procuring oxygen gas is readily effected by decomposing many of the substances which contains its base. Red-lead, which is the red oxide or rust of lead, or the

black ore of manganese, are oxides of these two metals. Nothing is more easy than to obtain oxygen gas from either of these two substances. The process follows:

Example. Procure a tub or trough A, (*plate fig.* 1.) with a shelf KK, on which BGF, are glass jars or receivers, which, as well as the tub, are filled with water: C and E are glass retorts, into which the manganese or red-lead, and a small quantity of sulphuric acid, are to be inserted. Apply the heat of a lamp to the bottom of the retorts, and in a few minutes the oxygen will rise in bubbles and fill the receivers, from which it will force down the water.

68. Oxygen gas forms about twenty-two parts in the hundred of the air we breathe, the rest being nitrogen or azotic gas, except one per cent. of carbonic acid gas.

69. Combustion requires for its maintenance the presence of oxygen gas. The quantity of caloric liberated during combustion, depends entirely upon the quantity of oxygen gas combined in a given space of time, with the combustible body.

Illustration. In the lamp of Argand, with a circular wick, the flame is derived from the ignition of the vapour of the oil, heated to a sufficient extent for that purpose. That air is necessary to the perfect combustion of this vapour, may be known by stopping the avenue to the interior part of the wick, by immersion of the lower part of the lamp in water, when considerable smoke will instantly appear, and the light be proportionably dimmed.

70. Oxygen gas has a strong tendency to unite with simple combustibles. It is an essential constituent of the acids: with sulphur

it forms the sulphuric, with carbon the carbonic, with phosphorus the phosphoric, and so on.

71. With hydrogen it forms water in the proportion of eighty-five oxygen, and fifteen hydrogen. It is singular that water, though perfectly insipid, contains more of the acidifying principle of oxygen, than any of the acids to the constitution of which it is essential.

Example. Acid, from acetum, vinegar, is yielded during fermentation. Thus, when wine, beer, or other similar fluids are exposed at a moderate temperature to the atmosphere, they absorb oxygen from it, and change to this acid.

72. Oxygen does not impart the acid character to all substances. Such as it does impart this character to, are called acidifiable bases.

73. The nomenclature of the acids varies according as the acidifiable base is saturated in the first or second degree with oxygen, and the compounds are distinguished by their termination in *ic* or *ous*.

Illustration. Sulphurous and sulphuric acids, phosphorus, phosphoric acids, &c. In these instances, the sulphur or the phosphorus combine with two different portions of oxygen, and yield in consequence acids similar to their base, but different as to their chemical properties.

OF HYDROGEN.

74. Hydrogen is one of the constituents of water; fifteen parts of hydrogen, and eighty-five of oxygen form this fluid.

Observation. The modern theory of chemistry ascribes to hydrogen as well as to oxygen, the acidifying principle. The following extracts are made in order to shew that this opinion is not fully admitted.

Dr Murray, in his paper of the 12th of January, 1818, observes, "That the progress of chemical discovery has shewn, that oxygen cannot be regarded as exclusively the principle which communicates acidity. The same property is in different cases communicated by hydrogen.—When water is obtained from muriatic acid gas, it does not necessarily follow that it has pre-existed in the state of water It is equally possible, *a priori*, that the elements of water may have existed in the gas. On this view oxymuriatic acid will be a binary compound of a radical, at present unknown, with oxygen; and muriatic acid, a ternary compound of the same radical, with oxygen and hydrogen. And when muriatic acid gas is formed from the mutual action of oxymuriatic gas and hydrogen, it is simply from the hydrogen entering into union," &c.

To this reasoning, *Professor Cooper*, (of the University of Pennsylvania,) makes the following reply:

"With respect to the acidifying character of hydrogen, I am not yet prepared to regard it as irrevocably settled. Even though Dr. Murray in his late paper on the theory of chlorine, seems willing to suppose that the elements of water, and not water itself, enter into the chemical constitution of muriatic acid, and that the water obtained is formed during the process of obtaining it. The theory is ingenious: But I see nothing that is gained by substituting ternary for binary combinations. The facts are as well explained on the latter as on the former theory; and

till new facts, inexplicable on the old doctrine, be discovered, I see no good reason for embracing a new one.

"With respect to sulphuretted hydrogen, Dr. Murray certainly talks in too strong language, when he says in his late memoir, that sulphur forms with hydrogen a substance *unequivocally* acid,—it takes away the colour of paper blued by litmus, but without turning it red. That it combines with alkalies is no more than sulphur does without the aid of hydrogen, unless indeed water be decomposed during the combination. But a part of the sulphur, in obtaining sulphuretted hydrogen, may well be oxygenated by the atmospheric air contained in the water employed during the process of making this gas—or even a part of the water itself may be decomposed and furnish its oxygen. These are difficulties in the way of the modern theory, which must be surmounted before Dr. Murray's opinions find full credit." *See Pref. to Thompson's Chem., last Philadelphia edition.*

75. The simplest form in which hydrogen is found, is in a state of combination with caloric, in the form of hydrogen gas.

Observation. A knowledge of the properties of hydrogen gas is therefore obtained, by an attention to the *habitudes* of hydrogen gas.

76. By almost all the processes in which water is decomposed, hydrogen is furnished, for, in most of these, the decomposing agent combines with the oxygenous portion.

Example 1. If water be gradually dropped through a gun-barrel, or iron tube, heated to redness in the middle, such water will be decomposed, the oxygen combines with the iron, converting it to its state of oxide, while the hydrogen passes off considerably pure from the opposite end in a gaseous form.

2. When red hot iron is plunged into water, a portion of this is decomposed, and hydrogen is yielded, known by its very peculiar smell and combustibility in atmospheric air, when a taper is presented.

77. Hydrogen gas is twelve times lighter than common air, hence it has been applied to the filling of balloons. The term is synonimous with *inflammable air*, but the last name is incorrect, inasmuch as that this gas extinguishes a taper plunged into it.

Illustration. It only kindles at the point where the accession of the atmosphere is permitted. It burns silently at the point of contact, but with loud explosion when blended with atmospheric air in certain proportions, and still louder when mixed with pure oxygen gas, in the proportion of two parts of the former, to one of the latter, by measure.

78. This gas is noxious to animals, but its camparative levity and immiscibility with the atmosphere carries it rapidly beyond the point whence any detriment would, generally speaking, arise from it.

Observation. It is thought to form the region of luminous vapours in the upper part of the atmosphere.

Experiment. To procure hydrogen gas, provide a vial with a cork stopper; through which pass a glass tube or piece of tobacco pipe. Into this vial half filled with water, put a few small iron nails, to which add of sulphuric acid a quantity equal to one third of the water. But as there will be a very considerable degree of heat excited, the acid must be cautiously added and in small quantities at a time. Replace the cork, and the hydrogen gas will be liberated through the tube. To which, after the atmospheric air in the vial is driven off, apply the flame of a candle, and the gas will immediately take fire and burn with a clear flame until the hydrogen in the vial is exhausted—But care must be taken not to apply the candle until the atmospheric air in the phial is driven off, or the consequence will be explosion.

Illustration. In this experiment a decomposition of the

water takes place; its oxygen unites to the iron and forms an oxide of iron, which combines with the acid and forms a sulphate, while the hydrogen, the other constituent part of the water, is driven off in the form of gas.

79. Hydrogen forms one of the constituents of pit-coal, whence it is capable of being disengaged, combined with carbon in the form of carburetted hydrogen gas.

Observation. This gas burns with a much less dim light than that of common hydrogen: indeed it is a light more grateful to the eye than any other. It has been commodiously adapted to the lighting of streets and houses.

Example 1. If a bladder, free from air, be moistened and compressed, having previously adapted a perforated cork to a tobacco-pipe stopper, this cork being inserted in the neck of the phial containing the materials for furnishing hydrogen, the bladder becomes readily inflated by that gas.

2. Adapt the end of a common tobacco-pipe to the bladder thus filled with hydrogen gas, and dip the bowl of the pipe in soapsuds, prepared as if for blowing up soap bubbles. Squeeze out small portions of gas from the bladder into these soapsuds, and the bubbles formed will ascend into the air with very great rapidity, until they are out of sight.

3. If a lighted taper or candle is applied to the bubbles as they ascend from the bowl of a tobacco-pipe, they will explode or burst with a loud noise.

Illustration. By the application of the flame of the candle in this experiment, the hydrogen in the soap-bubbles is burnt or decomposed, and forms water by uniting with the oxygen of the atmosphere. The noise made by the explosion, is occasioned by the atmospheric air suddenly rushing in, or collapsing upon the empty space left by the bursting or exploding of the gas bubble.

4. In every inflammation, according to the new theory, there is a union between the base of oxygen gas, and the combustible body. The investigation of this union has

given birth to the most interesting discovery of modern times, viz. the formation of water.

5. This formation of water may be exhibited by holding a cold tumbler over the flame of hydrogen gas, as it proceeds through a small tube.

6. In order to produce an imitation of the gas lights, pound a small quantity of coal into powder, and put it into the bowl of a tobacco-pipe. Cover the coal closely over with clay, and put the bowl of the pipe into the fire. In a few minutes a stream of hydrogen gas will issue from the end of the tobacco-pipe, which may be set fire to with a candle, or piece of lighted paper, in the usual way.

7. In the production of gas lights on a larger scale, the coal is put into an iron cauldron, and heat applied to it, when the gas ascends, and is distributed by means of metal pipes, into various apartments of a house, or through the streets of a town But a better method of obtaining carburetted hydrogen gas, for immediate use in parlours or sitting rooms, is to procure it from pitch or tar.

80. In the experiments upon the combustion of hydrogen gas, a dangerous explosion takes place, if care be not taken to keep the gas entirely free from any mixture of common air.

Experiment 1 Into a strong jar, introduce one part of hydrogen gas, and two parts of common air; the combustion will be attended with sudden explosion,

2. Into the same vessel introduce two parts hydrogen gas, and one of oxygen gas. The explosion of these is still more violent. As vessels are apt to break in these experiments, it is advisable to wrap a towel round the glass in which the explosion is to be made.

81. Carburetted hydrogen gas is that which is produced from the distillation of coal, as already described when speaking of the gas lights.

Observation. Dr. Henry has shewn, that the air in coal

mines called *fire damp*, is light carburetted hydrogen. The effects of explosion produced by this fire damp, have been long known; and of late years, by their frequency and extent, have been peculiarly terrible. By a single explosion in the Felling coalery, near New Castle, no less than 101 persons were destroyed in an instant, and nearly as many families plunged in the deepest distress. All the care taken to ventilate mines on the most approved principles, appeared insufficient to prevent the recurrence of such catastrophes. But a happy recent discovery of professor Davy's, effected by numerous ingenious experiments, has rendered the community an invaluable benefit, by the formation of a SAFE LAMP, which can be taken into mines where this air exists, without danger. It is composed simply of wire gause, in the shape of a cylinder, which covers the burning wick; and which, while it remits light, excludes the passage of blaze to the external air. The fire damp (being found by experiment to differ from other inflammable gases) will not inflame by iron wire heated red hot; so that the exclusion of blaze renders the lamp perfectly safe, although the wire becomes ignited.

The apertures in the gause should not exceed one twentieth of an inch diameter, and the thickness of the wire from one-fortieth to one-sixtieth of an inch.—The wire cylinder that serves as a cover to the lamp, and is fastened to it by a screw of four or five turns, should not be more than two inches diameter, and six and a half inches long. This is screwed on a cylindric box, containing the oil and the wick, and about two and a half inches in diameter. The gause cylinder is defended by six strong upright wires, fixed in the upper part of this box, and supporting a cylindric top of metal, to which is fixed the ring by which the lamp is carried. A small cylinder projecting from the side of the under part of the lamp, serves to convey the oil to the wick.

The whole is so perfectly simple, so easily used, and so little in danger from accident, that it is singularly accommodated to the circumstances in which it is to be employed.

82. Hydrogen gas, besides being combined with water, may also be combined with sulphur, phosphorus, and carbon. It is then called sulphuretted hydrogen, phosphuretted hydrogen, and carburetted hydrogen.

Experiment 1. The combination of phosphorus and hydrogen gas possesses the property of taking fire when exposed to the air of the atmosphere, but more beautifully when oxygen gas is used. The following is the method of making this gas.

2. Take two ounces of slacked lime, one dram of phosphorus, and half an ounce of water; put them into a small retort, and apply heat; the bubbles burst and inflame as soon as they reach the top of the water, and beautiful undulating wreaths of smoke dance through the air, expanding as they ascend, and exhibiting one of the most interesting experiments in chemistry.

A solution of pure potash will enable us to make this experiment with more ease Introduce into a retort a dilute solution of caustic potash, with a piece of phosphorus; these, when heated to boiling, exhibit the appearance described.

3 Beautiful flashes of light are produced when bubbles of phosphuretted hydrogen gas are received in jars of oxygen gas, as soon as they reach the oxygen gas. These phenomena arise from the very minute division of the phosphorus in the hydrogenous gas, by which it is disposed to unite with oxygen, wherever it is presented to it.

Illustration. The decomposition of water by phosphorus, when lime or alkali is presented, is much more rapid than when water and phosphorus alone are employed, because it is aided by the disposition there is in the earth or alkali, to unite with the acid to be produced by the decomposition of the water.

Observation. Phosphuretted hydrogen retains its qualities, if kept over mercury, but not if kept over water. In the latter case, after a short time, hydrogen only remains.

83. Sulphuretted hydrogen gas forms part of the fœtid effluvia which rises from house-drains, and is produced by the decomposition of animal and vegitable substances, containing sulphur and hydrogen.

Observation. It is this species of air which gives to certain mineral waters, such as those of Harrowgate, their medicinal qualities.

84. The fire-works formed by hydrogen gas may be produced of different colours, according as the substances with which the hydrogen combines, differ in their degrees of purity.

Illustration. Persons who are in the habit of exhibiting fire works with inflammable air, obtain it by different processes, each of which present some variety or modification of colour, from the substances accidentally dissolved in it. When obtained from æther, it exhibits a dense blue flame, in the act of combustion. Pure hydrogen gas is said to be destitute of smell.

OF CARBON.

85. Carbon, in its greatest state of purity, exists in the diamond.

86. It is most frequently to be met with combined with a certain dose of oxygen, in which case it is called charcoal.

Example. Expose wood of any kind, robbed of its bark, to a red heat, in a close vessel, till vapours cease to issue, and you obtain a black opaque and brittle substance, easily reduced to powder, without taste and smell, called charcoal. If you pound it, and wash away the salts it may contain with diluted muriatic acid, and after-

wards apply repeated affusions of cold water, and then dry it in a sub-red heat, you obtain it sufficiently pure for general purposes. Common charcoal, dried in an oven, will answer, where great nicety is not required. It is considered as being fixed in the fire, no heat being able to volatilize any considerable portion of it When newly made, it will absorb its own bulk of air. It also attracts and strongly retains a small quantity of water. The powder of fresh charcoal is strongly disposed to unite with the odorous particles of bodies, and the colouring matter of vegetables: it may be therefore employed to correct the bad smell of corrupted water, of oiled silk bags, of ill-conditioned ulcers, and even cancers, and of decayed teeth when used as tooth powder. It is employed to deprive vegetable infusions, and other substances, used in chemistry, of their colour; for the concentration of the acetic acid; and to give mellowness and maturity to newly distilled spirits. Its principal use is as a fuel, but it ought always to be remembered, that the gas which arises from burning charcoal, is the most insidious and deleterious that can be inhaled.

Illustration 1. Meat, which is a little tainted with putridity, on being rubbed over with charcoal, in powder, will immediately become sweet.

2. Throw a quantity of charcoal into water which has been long kept, or which has become foul by being in contact with putrid substances, and the water will become perfectly sweet in the course of a few hours.

Rubbing the teeth with charcoal when finely powdered will render them beautifully white, and the breath perfectly sweet, when its offensiveness has been occasioned from a scorbutic disposition of the gums.

87. Charcoal is the coaly matter left by vegetable bodies when heated in close vessels.

88. Charcoal is a powerful antiseptic, or enemy to putridity.

89. Charcoal is generally procured on

burning wood, with smothered heat, and extinguishing it when red-hot.

90. Neither moisture or air affect charcoal when kept cool, nor can it be destroyed by heat, unless there be a free access to the external air.

Illustration 1. The properties of charcoal in resisting the action of putridity, have suggested its application to casks for containing water during long voyages. The inner surfaces of the casks should be charred or burnt at the time of their manufacture.

2. The points of stakes or piles, intended to be fixed into the ground, are also charred in the same manner, and their durability is thus greatly increased.

91. Carbon is the principal constituent of fossil coal, and also of the woody fibre of vegetables.

92. Carbon enters into the composition of wax, oils, gum, and resins.

93. Carbon combines with iron in several proportions.

Illustration. Plumbago, or black-lead, of which the pencils are made, is a compound of iron and carbon, in the proportion of nine parts carbon, to one of iron. It has nothing similar to lead about it, unless its inquinating property, by which paper is so readily marked. In this combination, we have a metallic alloy, less cohesive than almost any other substance, mercurial amalgam excepted, whilst the very same ingredients, in different proportions, produce another alloy, *steel*, which has properties diametrically opposite, as it is capable of cutting the hardest substances, with few exceptions. Here the iron predominates. The softest steel is harder than the hardest iron. The process of hardening steel is called *tempering* or *attempering*, and consists in that novel ar-

rangement of the particles which is produced when steel while hot is plunged into cold liquids, as water. The colder the liquid, or the more sudden the operation of cooling, the harder will the steel be. Case-hardening is the superficial conversion of the surface of iron into steel by heating it in the contact with animal carbon in close vessels Bar-iron is converted into steel in the same way, only that powdered charcoal is the substance in which it is imbedded.

94. Carbon is the basis of the carbonic acid.

Illustration. When a piece of common charcoal is burnt, this acid is formed: it exists in the form of a gas, termed by the elder chemists fixed air. It is highly deleterious, and gradually privative of life, when breathed, even mixed with atmospheric air. It is similar to the gas yielded during fermentation, and is resident on the surface of vats of fermentating liquors.

95. Carbonic acid has a great tendency to combination. With earths, alkalies, and metals, it forms *carbonates.*

Illustration. It is also combinable with water: hence the acidulated mineral springs, as of Pyrmont, Spa, &c. It is this product which gives the agreeable zest to beverages, which are the result of fermentation. Small beer, bottled ale, cyder, and champaign, owe their grateful taste to the diffusion of carbonic acid in these beverages. It retains all the antiseptic properties of its base, carbon, and hence, the importance of it in putrid and other diseases of a septic tendency. It is much diffused in nature. The Grotto del Cani, and the Lake Averno, are remarkable for their quantity of this subtile fluid which they exhale. Because derived from the combustion of wood, it was named by Van Helmont, in the days of alchemy, gas silvestre.

96. The carbonate of most importance, is the carbonate of lime.

Illustration. Common chalk is such a carbonate, and only differs from other lime-stone, and from marble, in its want of compactness or texture.

Example. Chalk effervesces with acids, and generally speaking, all carbonates do the same. This effervescence betrays the disengagement of carbonic acid gas, on account of the superior affinity of the acid affused, producing the effect.

97. Carbonic acid gas is nearly twice as heavy, bulk for bulk, as atmospheric air. Animals die in it.

Illustration Much of the inconvenience, perceived by the unfortunate parties who were the victims of suffocation in the black-hole, at Calcutta, might be referred to the carbonic acid gas, which always accumulates when rooms want ventilation, and when crowded audiences necessarily furnish contamination. The paleness of complexion, where, intent on his pursuits, the student breathes in close deleterious gas,

"Companion of the midnight-lamp,"

is distinctly marked. Want of attention to these circumstances is no compliment to the philosophic days in which we have the satisfaction to live.

How frequent are the accidents which take place in breweries, by the ill timed descent of workmen into vats still filled with fixed air, which is there, from its weight permanently lodged!

98. Carbonic acid generally constitutes a considerable portion of the atmosphere of cellars, wells, mines, &c. which have been long excluded from the external air.

99. Charcoal, and all substances which contain it, yield carbonic acid during combustion.

Illustration. In compound combustibles, the quantity of carbonic acid produced, is, during their combustion,

as the actual quantity of carbon or charcoal which such bodies contain.

Experiment 1. To procure carbonic acid gas, pound chalk, which is a carbonate of lime, and put it into a glass retort or phial. Pour on it sulpuric acid largely diluted with water. The lime having a stronger affinity for the sulphuric acid, will unite to it, and will form a sulphate of lime, which is Plaster of Paris, while the carbonic acid gas will be driven off in great abundance, and may be collected in jars or tumblers.

2. When there is reason to apprehend the existence of carbonic acid gas in wells or other deep places, before attempting to enter them, a lighted candle should always be introduced. If the flame becomes extinguished there is no doubt of the existence of this gas, and in order to remove it, quicklime should be let down in buckets and gradually sprinkled with water. As the lime slacks, it will absorb the carbonic acid gas, and will render the air pure.

3. The action between nitric acid and charcoal is very singular. If very fuming acid be made to trickle down the sides of a glass vessel containing dry charcoal powder, the carbon unites to the oxygen of the acid with such rapidity as to produce inflammation. The glass should first be slightly warmed.

4. When charcoal is burnt in oxygen gas, nearly the whole of it disappears, and the carbonic acid of the new nomenclature appears. The charcoal being made red-hot for this purpose, is to be placed upon a dish, and introduced into a jar of oxygen gas. It burns with great brilliancy. When combustion ceases, pour into the glass a small portion of water, containing the tincture of litmus, and it will be converted to a red, intimating the formation of acid, during the combustion of the charcoal.

5. Counterpoise a large funnel of paper, in a pair of scales, and pour carbonic acid into it, from the spout of a jar, as you would do water, when the descent of the balance shews that this gas is heavier than atmospheric air.

6. Poured upon a taper, it extinguishes the flame as water would do.

Observation. Whatever refuses to maintain combustion, is not subservient to respiration; but as animals plunged into this gas instantaneously perish, it appears not only to be negatively, but positively, fatal, for azotic and hydrogen gases may be breathed several times without much mischief.

Ex. 7. Into a jar, full of mercury, inverted over the mercurial apparatus, introduce equal measures of carbonic acid gas and water. Agitate them together, and the gas will be absorbed. The water not only reddens blue vegetable colours, but is acidulous to the taste. As the acid is but loosely combined, heat readily expels it from the water, restoring the blue.

8. Place a lighted candle on the surface of lime-water, and invert over it a glass vessel, either containing common air or oxygen gas. The water will rise in the jar when the flame is extinguished, and become milky.

9. If a small animal be confined in the same situation, the same effect will be produced. Respire by a tube through lime-water, and the lime will be instantly precipitated.

10. When plants, as a sprig of mint, is made to grow in carbonic acid, it reduces this to pure oxygen gas, attaching to itself its carbonaceous base.

Observation. Carbonic acid gas enters into the composition of cyder, perry, bottled beer, and other fermented liquors; and occasions the briskness or sparkling, (as well as grateful taste,) observed in these fluids.

OF THE METALS.

100. *Metals* are distinguished from other bodies by their weight, opacity and splendour; also by their property of conducting the galvanic or electric fluids.

101. The closeness of their texture, their ductility, and malleability, and the power which all have to reflect light when polish-

ed, fit them for being converted into various utensils, both for the purposes of common life, and the different arts.

102. Metals are the heaviest of all bodies.

Observation. This applies only to such as are already known.

Example. Tin, bulk for bulk, weighs seven times as much as water, and platina nearly twenty-three times as much.

103. The metals are incapable of transmitting light through their substance.

Observation Gold, however, when very finely laminated, does transmit light.

104. They are remarkable for being conductors of heat and electricity.

105. The most common and best known among the metals, may be beat into any form, under the hammer, without cracking or crumbling. This property implies their malleability.

Observation In whatever manner we extend the surface of a metal, though previously cold, it is found to wax warm and become rigid, and refuses, under rollers, to extend further We restore it to its former pliancy by heating it, and allowing it to cool gradually. This is called *annealing* it. When it has been again extended, more heat becomes sensible, and is lost, and this must be again restored if we would wish to extend it further.

Illustration. When metals are subjected to heat, they expand in every direction, and all in different proportions. When the temperature is more increased, they become liquid, and, if in mass, present a convex surface, if in small drops, they are globular, as in the case of metals fused at the blow-pipe. If the temperature be increased

considerably beyond that necessary for fusion, they may be sometimes volatilized unchanged.

Example. Mercury is evaporated at 600°, but is concrete at *minus* 40°. Lead melts at a heat below the boiling point of mercury. Iron, at a strong white heat, becomes a sort of liquid paste; and platina cannot be fused in the greatest heat which can be produced in our furnaces, but requires the aid of a blow-pipe and oxygen gas.

106. *Metals* are converted into a fluid state by the addition of caloric. This is termed *fusion*.

Observation. Some are always in that state, even at almost all known temperatures, as mercury.

107. When the heat is long continued in the *open air*, most of the metals become rusted, or assume a cinder-like appearance, by attracting that part of the air called oxygen.

108. They are then called oxides of the metals, and are said to have been oxidized.

109. In the state of oxides or rust they may be dissolved in water and other fluids, in order to form dyes, painters' colours, &c.

Example 1. Copper becomes oxidated by being made red-hot, and exposed for a time to the atmosphere in that state.

2. Coiled iron-wire also, when heated for some time to redness in the bowl of a tobacco-pipe, loses its metallic splendour, and crumbles into a rust or oxide of iron.

3. Antimony being exposed to a red-heat, on an iron plate, and a stream of oxygen gas pressed from a tube attached to a bag containing it, upon its surface, becomes converted, with a beautiful appearance, into the oxide of antimony.

4. Zinc, exposed to a red-heat in a crucible, exhibit

combustion, oxidation, and sublimation of the oxide, which when cold, is beautifully white and delicate.

5. Wrap the finest harpsichord-wire round a watch-spring, ascertain its weight, set it upright in a copper dish, in a jar of oxygen gas, inflame a bit of cotton, dipped in wax, and attached to the upper end of the wire, when a beautiful conflagration will ensue, and the metal will be found, in a state of oxide, to have increased in weight.

110. Gold, silver, and platina, were called noble metals, it being suspected that they could not be oxidized or altered by fire and air.

Observation. Metals are also oxidized by being immersed in the substances called acids, which part with their oxygen or acidifying principle to the metals, and reduce them to oxides.

111. A metallic oxide is generally in powder, resembling earth.

112. Oxides weigh more than the metal from which they are produced.

Illustration. If we melt one hundred pounds weight of lead in the open air, and keep it in a melted state until it is oxidized or changed into red-lead, it will be found to weigh one hundred and ten pounds. It has therefore imbibed ten pounds weight of oxygen from the atmosphere.

113. Metals, in the state of oxides, may be brought back to their metallic state. This process is called *reduction.*

Illustration. As charcoal has a stronger attraction for oxygen than any of the metals, mix up some common red lead (oxide of lead) and charcoal, and expose the mixture in a shovel upon a strong fire. When the shovel is nearly red hot, the charcoal will be found to have robbed

the red lead of its oxygen; common lead will be found in a melted state.

Observation 1. There are some oxides of metals that attract their contained oxygen so feebly, that the action of heat alone is sufficient for their reduction.

2. Mercury, by a long and patient application of a moderate heat, changes to the red oxide of mercury, called formerly *precipitate per se*, because obtained without any visible addition.

Illustration. During this process, oxygen is always absorbed from the surrounding air, and a proportionate weight is acquired.

Example. This red oxide, being exposed to a higher degree of heat, abandons the oxygen for which it had no longer any attraction. The oxygen passes off in the form of oxygen gas.

Illustration. It is upon this principle that oxygen gas is obtained by exposure to heat alone of the black oxide of manganese, which, of almost all substances, yields oxygen most abundantly, at least at the simplest cost.

114. The metals combine or unite with sulphur, phosphorus, and carbon. These combinations are called sulphurets, phosphurets and carburets.

115. The metals after being oxidized are dissolved by most of the substances called acids, and form solutions.

116. The solution of the metals in the acids, is attended with effervescence and heat, and in cases where the water is decomposed and not the acid, hydrogen gas is emitted.

117. The oxides of the metals readily unite with glass when melted together, and give it all the different tinges, by which it is made to resemble gems, or precious stones.

118. Compounds of two metals are more easily melted than when separate, and on this account are used for soldering.

Illustration. The solder used for gold workmanship, is a mixture of gold and silver, and for silver a mixture of silver and copper.

119. Compounds of metals oxidize much more readily than separate metals.

120. No metals are found in a pure state, except gold, silver, copper and mercury.

121. They are found in the state of ores, or mixed and blended with earths and other substances.

122. Sometimes the ore is a pure oxide, and requires a simple operation to separate the oxygen from the metal.

Illustration. The brown, or orange coloured earth called ochre, is an oxide of iron. Mix some of it with charcoal, and make the mixture red hot, the charcoal will take off the oxygen, and pure iron will remain.

123. Metals are found in nature in various states. When uncombined, or when combined only with each other, they are said to be in a native state. When combined with other substances, so that the metallic properties are in some measure disguised, they are said to be mineralized, or in a state of ore; this ore is usually mixed with various earthy fossils, such as quartz, fluor spar, &c.

Illustration. The ore may be separated from the accompanying fossils by being pounded with hammers or stampers. It is then washed on an inclined plane, by

which means the water carries off the earthy substance, and the metallic matter remains behind. After this operation, the ore, if it contain sulphur, arsenic, or any acid, is subjected to a low red heat, which is termed roasting it, by which any of these substances is expelled. The metal is then reduced by placing in a furnace alternate layers of the charcoal, and the metallic substance. A strong heat is excited by bellows; the carbonaceous matter attracts the oxygen with which the metal is combined, while the pure metal runs out at the bottom of the furnace.

124. Gold, platina, silver, mercury, copper, iron, tin, lead, nickel and zinc, are called malleable metals, and may be beat into any shape with the hammer.

125. Bismuth, antimony, tellurium, and arsenic, are called brittle metals, that may be easily fused or melted.

126. Cobalt, manganese, tungsten, molybdena, uranium, titanium, chrome, columbium, tantalium, cerium, and nickel, are fused with difficulty.

127. Besides the metals above mentioned there are four distinct ones, which have been found to exist associated with platina, viz. iridium, osmium, rhodium, and palladium.

128. *Gold* is the more ductile and malleable (that is, more easily beaten out with a hammer), than most of the metals.

129. It cannot be changed, rusted, or oxidized by the application of the common heat of a furnace, or by exposure to the air or water.

130. Gold may be dissolved in the acid known by the name of *aqua regia*, called in chemistry nitro-muriatic acid.

Ex. Dissolve a piece of gold, or gold leaf, in aqua regia, and afterwards immerse a sheet of tin in the solution. The gold will adhere to the tin in the form of beautiful purple powder, which, when scraped off, is the powder of cassius, so much used in painting and enamelling. This is an oxide of gold.

131. *Platinum*, or *Platina*, is found in the mines of Peru, in South America. It is heavier than gold, and is therefore the heaviest substance in nature.

132. Platina is of a dull silvery, or grey colour, and is inferior to gold in point of malleability.

133. It is melted or fused with more difficulty than any of the other metals, requiring a much higher degree of heat, and has been sometimes used for chemical utensils, such as crucibles, spoons, &c. which will resist the strongest heat that can be excited in our ordinary furnaces.

134. Platina combines with most other metals. It is harder than any other metal, iron excepted.

Illustration 1. Mirrors for telescopes are made of it, of exquisite beauty. The Spaniards are in the habit of mixing it with iron, in order to form gun-barrels, which are said never to rust, and which are much stronger than iron barrels alone. It gives to iron a remarkable toughness. It may form a valuable coating for copper and iron, and will hereafter become precious for the formation of coins and medals.

2. Platina, in its malleable state, may be cut with a knife.

3. With steel, platina forms an alloy, not to be touched with a file.

135. *Silver* ranks next to gold in beauty and malleability.

136. Its uses in chemistry are confined to its operation when dissolved in nitric acid (aqua fortis).

137. A solution thus formed, is called *nitrate of silver.*

Illustration. It will dye red hair of a fine black, if the hair is bathed with it once or twice, but the solution should be diluted with water, otherwise it will burn the skin.

138. When the water of this solution is evaporated by being boiled, a solid substance remains, called *lunar caustic*, which burns or corrodes almost every substance with which it comes in contact.

139. The nitrate of silver may be decomposed, or the silver restored, by other metals being thrown into the solution.

Ex. 1. If we procure a smooth piece of copper, and dip it in a solution of silver, as above prepared, the copper will be covered with silver. In this way the operation called plating is performed.

2. Fill a glass phial with solution of silver, and drop into it a small quantity of quicksilver; the silver will fall towards the bottom, or be precipitated, and as the particles of the silver and the quicksilver have an attraction for each other, the precipitate will assume the form of the branches of a tree. This has been called Diana's tree.

140. *Mercury*, or *Quicksilver*, is distin-

guished from every other metal, by having so strong an attraction for caloric or heat, that it remains fluid in the ordinary temperature of the atmosphere.

141. It may be frozen or rendered solid, however, by applying a great degree of cold to it. In this state it is a ductile and malleable metal, resembling block tin.

142. Mercury combines easily with sulphur, and the compound is then called sulphuret of mercury.

Illustration. Put some sulphur and quicksilver into a shovel, and make the whole red-hot over a strong fire, the beautiful paint called *vermillion* or *cinnabar* will then be produced, which is a sulphuret of mercury.

143. *Cinnabar* is found in a natural state, and is considered as an ore of mercury.

144. Mercury unites with other metals, but the proportion of the mercury must be always the least.

145. The union of mercury with another metal, is called an *amalgam*, which is generally soft, and of the consistence of butter.

Illustration. The silvering used for looking-glasses is an amalgam of tin and mercury. Tinfoil is spread over the glass, and fluid mercury poured upon it. The metals are made to unite, or are amalgamated, by being pressed together with weights.

Observation. Mercury is used also in the construction of barometers, thermometers, and in medicine. A fulminating mercury has been of late discovered.

146. *Copper* is hard, sonorous, highly malleable, and ductile, of a ruddy brilliant colour.

147. If exposed to a very strong fire, it emits white fumes, and burns with a green flame of great beauty and brilliancy.

148. Copper is used in the arts connected with chemistry, when united with the substances called acids.

Observation 1. All the salts of copper are poisonous, therefore great care should be taken not to taste wantonly the solutions. Utensils made of copper or brass, are, if possible, to be avoided, for culinary purposes. Zinc, tinned iron, and pottery, are cheap and proper substitutes.

2. The neutral salts, formed by this metal and the acids, are either of a beautiful blue or green. With the sulphuric acid, *blue*. The nitrates, muriates, and acetates, are *green*.

Experiment 1. Moisten the surface of a penny-piece with a solution of nitrate of mercury, it instantly appears as if covered with silver.

2. Ammonia precipitates the copper of the sulphate of ammonia. This precipitate is of a whitish blue, but it dissolves almost the moment it is formed, and there results a liquor of an exceedingly fine azure blue, formerly called *aqua cœlestis*.

3. Iron precipitates copper from its solutions in a metallic state. Dip a knife-blade, free from grease, into a solution of sulphate of copper, and it appears to be transmuted into that metal.

Illustration. When a piece of copper is put into acetic acid (vinegar), the copper takes the acid matter of oxygen from the vinegar, and the substance called verdigrise is formed, so much used by painters. This is called an acetate of copper.

149. Copper combines, or may be alloyed with most of the metals.

Illustration. The gold coin of all countries is alloyed with a certain quantity of copper, to render it more durable.

Observation. *Brass* is an alloy of copper and zinc, in the proportion of three parts copper, and one zinc. Bell-metal contains silver, which is thought to add much to its sonorousness. Copper, with iron, forms the *elderado*, or Mr. Keir's patent metal for window frames, which possesses at the same time elegance and strength, little obstructing the light, when wrought into the requisite shape.

150. Copper, united with the metal of zinc, in the proportion of three parts of copper to one of zinc, forms the compound called brass.

151. *Iron* is the most abundant of the metals. It has a peculiar taste and smell, but which are not pernicious.

152. It is the toughest of all the metals, but is less malleable than gold, silver, or copper.

153. Iron is always found in the state of an ore, or in other words an oxide of the metal, mixed with earth.

154. It is separated from the ore by being melted along with charcoal, in a furnace.

155. When in a fluid or melted state, it is run into moulds, and is then called pig, or cast iron.

156. Cast iron, upon being made red-hot and beaten with hammers for some time, becomes wrought iron, and is made into bars.

157. Steel is iron combined with about one-sixteenth part of its weight of the substance called carbon.

Illustration. There are three kinds of steel, known by

the names of *natural steel, steel of cementation, and cast steel. Natural steel* is prepared by simply heating cast iron, for a certain time in a furnace *Steel of cementation*, or blistered, as it is sometimes called, is prepared by covering bars of wrought iron with powdered charcoal, and heating them in a close furnace for eight or ten days. *Cast steel* is made by heating blistered steel in the same way, in the midst of a quantity of chalk.

158. Iron combines with the sulphuric acid. The compound is the *sulphate of iron*, (green vitriol or copperas).

Illustration. This substance has the peculiar property of striking a black with the astringent principle contained in the gall-nut, tanner's bark, green tea, oak saw-dust, &c. and hence forms the black dye for hats, clothes, &c.

Experiment 1. With infusions of galls it forms the ink with which we write.

Illustration. The more oxygen the iron contains, the deeper the black produced. Hence ink becomes blacker after it is written, for its constituent, iron, continues to absorb its oxygen from the air, until it be wholly saturated.

Experiment 2. With the Prussic acid, sulphate of iron forms a beautiful blue. This is the Prussian or Berlin blue.

3. Steel filings and sulphur mixed, and moistened with water in a few hours become hot, the water is decomposed, its oxygen corrodes the iron, and converts the sulphur into acid, while its hydrogen flies off in the form of gas

Observation 1. The heat increases sometimes to such a degree as to cause the mixture to burst out into flames. This has been considered as an artificial volcano Iron gives the medicinal value to Chalybeate springs, as of Cheltenham, Tunbridge, &c.

2. "The knowledge, treatment, and modification of iron, in its different states, by rendering it the most useful of metals, have great influence on the happiness and power of nations. The perfection of iron works follows

the degree of civilization of man." Iron is the only metal which could not be dispensed with in the present condition of the arts.

159. *Tin* is a metal extremely malleable, but it is inferior to most others in ductility.

160. It unites or combines with almost all the other metals.

161. When mixed with copper in different proportions, it forms bronze, bell-metal, and the materials of which cannons are made.

162. It is also used for tinning various metals, to prevent their tarnish or oxidation.

N. B. Copper should be always tinned when used for culinary purposes.

Experiment 1. Tin, when melted in a crucible, into which a piece of clean iron, as a knife-blade, being dipped, comes out perfectly tinned.

2. Tin, rubbed over the surface of a plate of copper, it will assume a silvery appearance, becoming completely covered with a coating of tin.

3. For galvanic experiments, in the construction of the compound plates of zinc and copper, union is effected by a solder of simple tinfoil, interposed between the two metals, and then heated.

4. The action of fire being continued after tin becomes fused, it oxidates. This oxide of tin is termed tutty, or putty, and is used for the purpose of giving a high polish to glass.

5. Fused at the blow-pipe with glass, the white oxide of tin, or tutty, yields a white enamel.

6. Nitric acid oxidates tin, (in leaves or foil) very greedily, and allows it to precipitate in the form of white oxide of tin.

7. Sulphuric acid dissolves the nitrate of tin, which has the property of being again precipitated by water.

Observation 1. The scarlet-dye, or bright red of the dyers, depends upon the solution of tin in the nitro-muriatic acid.

2. It is remarkable that tin, when combined with other metals, antimony excepted, forms an alloy of greater specific gravity than the heavier metal with which it is combined.

163. *Lead* is a heavy metal of a pale livid white colour. It is the softest and least elastic of all the solid metals.

164. By the joint action of heat and air, lead becomes oxidated, and exhibits different colours, according to the proportion of oxygen with which it may have combined.

Illustration. Massicot, litharge, and *minium,* or red lead, are oxides of lead, but these three colours contain different proportions of oxygen. Massicot the least, and minium the largest portion.

Experiment 1. Litharge, urged by a strong fire, melts into a yellow glass.

2. Lead, exposed in thin slips to the fumes of vinegar or the acetic acid, is converted at the surface into white flakes, which is the purest white-lead when ground, or *flake-white.*

Observation 1. Lead is commonly found mineralized with sulphur, forming sulphuret of lead, or *galena.*

2. The oxides of lead are used in glass works, to facilitate the fusion of the glass, to render it heavier, softer, and more fit to be cut or polished.

Example 1. The oxides of lead being fused with carbonaceous matter, as on charcoal at the blow-pipe, are revived.

2. All the oxides of lead are soluble in vinegar, and the compound has a sweet styptic astringency, much disguised, and known with difficulty by the palate when tasted.

Illustration. Hence, to wines having become sour, it is not unusual to add flake-white, which neutralizes the

acid only; such wines when drank are highly detrimental to the frame. Palsies, lock-jaw, and dreadful affections of the bowels are among the train of evil which such disguised and baneful beverages occasion. Indeed it is a notorious fact, that workmen, accustomed to the grinding of colours, are sooner or later afflicted with the disease termed *painter's cholic*.

165. Lead, mixed with tin, forms pewter, which has different degrees of hardness, according to the proportions employed.

Observation. Lead has various uses in the arts; for pipes to convey liquids, cauldrons, &c the inside of boxes, and it is sometimes alloyed for lining tea chests: houses are covered with it. It is also employed for the purpose of making shot and bullets. It is a customary, but fraudulent practice, to mix it with tin for tining culinary utensils.

166. *Nickel* is a whitish metal, found in Germany, but is most abundant in China.

167. The Chinese call it white copper, and form it into utensils, but it has never been applied to any useful purpose in Great Britain.

168 *Zinc*, or *Spelter*, as it is called by the English workmen, is found in the stone or substance called calamine.

169. It is of a shining bluish white colour, and has been recently used when beat out into plates, for covering the roofs of houses.

170. When mixed with copper this metal is used in making brass, pinchbeck, &c. It is also the base of white vitriol, which is a sulphate of zinc.

171. When made red-hot, it emits a bril-

liant bluish light; and white flakes, resembling wool or snow, ascend into the air.

Illustration. The beautiful blue stars, exhibited in fireworks, are produced by mixing zinc in filings, with gunpowder.

172. *Antimony* is a metal of a dusky white colour, procured in Hungary and Norway.

173. In its metallic state, it is used, when mixed with lead, for making printer's types, to which it imparts hardness.

174. When in the state of an oxide, it is used in medicine, but requires to be applied with caution.

Experiment 1. When exposed to heat sufficient to melt it in the open air, it shews its combustible nature, and emits a white smoke, which when condensed, is called the silver or snow of antimony. It is an oxide of that metal.

2 If this oxide be excluded from the external air, and fused, it assumes a glassy appearance, and is called the glass of antimony

3 To a boiling solution of pure potash, add some of the crude antimony of the shops, which consists of sulphur and antimony The alkali combines with all the sulphur, and part of the metal. Neutralize the alkali by the addition of the sulphuric acid, and it will unite with a larger proportion of sulphur than it was originally combined with, and fall down in the form of *golden sulphur of antimony.*

This has been in high esteem as a medicine, but the principal uses of antimony are in *speculum metal,* type-metal, and the finer sort of pewter It combines readily with other metals, gold excepted.

175. *Bismuth* is not malleable like other metals. It crumbles into powder when struck

with a hammer, instead of spreading into thin plates.

176. It is found mixed with the ores of the metal called cobalt, in the mines of Saxony, and is also used for making printer's types, when united with lead.

177. When mixed or alloyed with some other metals, it renders them so easily fused, that the composition will melt in boiling water.

Ex. Melt four ounces of bismuth, two and a half ounces of lead, and an ounce and a half of tin together, in an iron ladle, over the fire. When the composition cools, tea-spoons, or other articles may be shaped out of it, and if put into hot tea, or water, they will be immediately melted, and will fall into a solid mass, to the bottom of the tea cup.

178. *Arsenic* is sometimes found native, but generally combined with other metals.

179. Under every form it is poisonous, although it is sometimes used in medicine in very small quantities.

180. It burns in the fire with a bright flame, and emits an odour resembling that of garlic.

181. When mixed with copper, it forms a white metal, which is capable of being plated with silver, to great advantage.

182. When combined with sulphur, it furnishes a variety of valuable dyes, or colours.

Illustration 1. Orpiment, or the substance from which the beautiful colour called King's Yellow is made, is sulphuret of arsenic.

2. *Realgar*, being the dye stuff which yields a dark orange, or scarlet, is a similar compound of arsenic. Both are used by dyers and painters.

Observation. Most of the preparations of this metal, are in a high degree noxious; therefore, to ascertain the presence of arsenic, in many instances of *forensic* medicine, is a matter of moment. Arsenic may even, at first sight, be taken for sugar. If any suspicion arise, it may be cleared up by throwing some of it in the fire: the white smoke and the garlic smell, discover the arsenic. If the misfortune of swallowing some arsenic should take place, the following is said to be a direct antidote:—A drachm of sulphate of pot-ash, or vitriolated tartar, is to be dissolved in a quart of water, to be drank by the sick person at several draughts; the sulphur combining with the arsenic, destroys its noxious quality.

Example. In its metallic state, it enters into the composition of several alloys, for the formation of *specula*. It is used in making small shot, to render the lead more capable of running into granules. It is also employed, like many other metals, in dyeing and calico-printing; it enters into the composition of some sorts of glass, and forms several excellent pigments. Besides these uses, it is employed in medicine. It is the basis of white enamel, as also of the faces of watches in general.

183. *Cobalt* is a greyish brittle metal, resembling steel.

184. It is used in the state of an oxide only, for making colours.

Illustration. The blue colours given to earthenware, porcelain, glass, and enamels, is produced by the application of zaffre, or oxide of cobalt, wrought up into a kind of paint. It is also called *smalt* by painters.

Example. The muriatic acid dissolves the oxide of cobalt with great facility. This solution is of a sub-red, and, when evaporated, affords pale green chrystals, soluble in spirts of wine, and decompoundable by fire.

Observation. This solution, as well as the aqua regia solution of cobalt, possesses the singular property, that

when diluted with water, and used as an ink, the letters are invisible, but appear of a beautiful green colour when heated. This sympathetic ink is best prepared by adding culinary salt to a solution of nitrate of cobalt, for thus the nitric acid is changed into an aqua regia, and the nitrate of soda, produced at the same time, prevents the paper from being corroded.

185. Ammonia dissolves zaffre, or the ore of cobalt, and the result is a liquor of a fine red.

186. *Manganese* is never found except in the state of a black oxide.

187. It is never applied to any use in its metallic state.

188. It is therefore used to produce an oxide: it contains forty per cent. of oxygen, which it can be made to give out by the application of heat.

Illustration. In the highest state of oxidation, manganese, like most other metals, is not soluble in acids. If you pour the nitric acid upon it, there is therefore no action, but if the oxide be mixed with some inflammable substance, as sugar, which can combine with a portion of oxygen, it is then dissolved. If the sulphuric acid be poured upon it, and heat be applied, the excess of oxygen is driven off, in consequence of an attraction between the acid and the less oxidated metal, and the sulphate of manganese is produced. If the muriatic acid be employed, part of the acid combines with the excess of oxygen, and forms the oxymuriatic acid, and part forms the muriate of manganese, with the oxide thus rendered capable of saline combination.

189. Black oxide of manganese is used to produce oxygen gas, or to add a higher degree of acidity to substances already acid, by

communicating to them a stronger portion of oxygen, or the acidifying principle.

Observation. Alkalies precipitate a light coloured oxide from these salts, which attracts oxygen, and becomes dark by exposure to the air Alkalies also combine with manganese, and, if the fixed alkalies are used, form the mineral chamæleon.

Experiment. Mix an ounce of powdered nitre, with six drachms of the black oxide of manganese, and expose them to a red heat in a crucible, until no more oxygen is produced. There then remains a dark coloured mass, remarkable for the variety of colours it produces when different quantities of hot water are poured on it. Put a small quantity of it into a glass vessel, pour in a little water, and the colour will be green. Add more, and the colour becomes blue, a third portion makes it purple, while a few drops of the sulphuret of lime destroys its colour, by robbing it of its oxygen.

Observation. Oxide of manganese is used in the glass manufactories, to clear the glass of its green or yellow hue. For this reason it has been called glass-maker's soap. It is likewise used to give a violet hue to glass and porcelain.

2. Iron is always found in the materials from which glass is manufactured, and in a low state of oxidation gives to the glass a green tinge. But if it is at a higher degree of oxidizement, it either does not enter into the fusion with the ingredients of the glass, or at least it does not communicate colour. Manganese, on the contrary, in the state of a black oxide, gives a violet colour; while, when reduced to the white oxide, the glass is colourless. In adding, therefore, a proper quantity of the black oxide to the glass, it yields its oxygen to the iron, which it brings to a high state of oxidation; while it passes, itself, to the state of white oxide; and thus each metal is in that state in which it does not communicate colour.

190. *Chrome* exists in the state of an acid. combined with an oxide of lead, in the red-lead ore of Siberia. It derives its name from

the splendid and numerous colours which it presents in its saline combinations.

191. Chromate of iron is said to have been discovered in France and in Siberia.

192. The combinations of chromic acid with metallic oxides in general exhibit the most beautiful colours, which are well adapted to form the finest paints. With the oxide of lead it produces an orange yellow of various shades; with mercury, a vermillion red; and with zinc and bismuth a yellow. This metal combined with iron has lately been found in the neighbourhood of Baltimore in large quantities.

Note. The specific gravity of platina is as 23—water being unity.—The specific gravity of gold 19—of silver $10\frac{5}{10}$,—of mercury $13\frac{6}{10}$,—of lead $11\frac{3}{10}$—, of copper $8\frac{5}{10}$,—of iron $7\frac{7}{10}$,—of tin $7\frac{3}{10}$,—of zinc 7—of antimony $6\frac{7}{10}$,—of bismuth $9\frac{4}{5}$,—nickel $8\frac{9}{10}$,—arsenic $5\frac{7}{10}$,—cobalt $7\frac{8}{10}$, and of manganese 7.

193. The rest of the metals enumerated in the beginning of this section, have never yet been applied to any useful purpose, and their chemical properties are but slightly known.

OF NITROGEN, OR AZOT.

194. This is the basis of the nitric acid: it exhibits itself in its simplest state as a gas. Though the term azot be here set down as synonimous with nitrogen, yet it is rejected as equivocal; for every gas, which,

when respired alone, does not maintain life may be called azotic. It combines with oxygen, forming two oxides and an acid.

195. In the state of gas it forms about seventy-eight parts in the hundred of atmospheric air (including one per cent. of carbonic acid gas) and is that part of the common air which supports neither flame nor animal life.

196. It may be readily obtained from atmospheric air, by removing the oxygenous portion.

Example 1. If a portion of iron filings and sulphur, moistened with water, be put into a flask filled with common air, the oxygen will be absorbed in a day or two by the metal and the sulphur, while the nitrogen gas will remain.

2. The same effect will be produced by phosphorus alone, inclosed in a similar vessel, along with common air. The phosphorus will be oxidised or converted into phosphoric acid, and the nitrogen gas will remain behind.

197. Nitrogen gas is considerably lighter than common air, and consequently much lighter than oxygen gas.

198. As nitrogen gas is equally privative of life, and the maintenance of flame, so, when it is possible to exclude the external atmosphere, damage by fire might often be prevented. It was the mephitic air of the ancients. One hundred cubic inches of it weigh $30\frac{2}{3}$ grains, while one hundred cubic inches of oxygen gas weigh $34\frac{1}{2}$ grains. It does not prevent vegetation; it is evolved from animal and vegetable bodies; with

oxygen gas, exposed to the electric spark, it forms the nitric acid.

Observation. It is from the above circumstance, that the most effectual and instantaneous method, as well as the safest, for extinguishing fire in a chimney, is to place a wet blanket before the opening at the bottom, [fire place], so as to exclude the atmospheric air.*

199. Nitrogen unites with oxygen in two states, in the mixture of which the atmospheric air is composed, and in the chemical combination of the nitric acid.

200. *Nitrous acid* was supposed to be nitrogen, oxigenated in a less degree than the *nitric acid*, but it is well ascertained now, that it is no more than mere nitric acid, holding nitrous gas in solution.

Observation. It varies singularly in its colour, according to the quantity of nitrous gas held in solution.

201. *Nitrogen gas* extinguishes flame, which can alone be maintained by oxygen gas, or by gases which contain it.

202. There are two combinations only of nitrogen and oxygen in a gaseous state; nitrous oxide and nitrous gas.

203. Nitrous acid is the *aqua fortis* of commerce.

204. Nitrous gas is formed of fifty-seven per cent. of oxygen, and forty-three of nitro-

* Were sliding plates, (made air tight), introduced into our fire places, so as to close the opening when occasion required, they would form a very great safeguard, and prevent numerous accidents.

gen. When in contact with common air it greedily absorbs its oxygen, visible vapours and an acid taste are produced.

OF PHOSPHORUS.

205. Phosphorus may be obtained by decomposing the bones of animals: it is a yellowish, transparent substance, like beeswax, and fuses in water slightly heated.

Experiment. If a bit of phosphorus, the size of a millet seed, be put upon the outside of a Florence flask, when hot water is put into the flask, the phosphorus on the outside spontaneously kindles.

Observation. A very slow combustion of phosphorus continually goes on, very perceptible in the dark. Indeed phosphorus derives its name from this quality.

Experiment 1 When moderately heated phosphorus burns rapidly, with a brilliant light, in common air; and, as in other combustions the oxygen and inflammable substances unite, so in this, the oxygen and phosphorus combine and form an acid.

2. Dissolve phosphorus in oil or æther, the former makes the face and hands shine when rubbed on them; the latter, when poured in small quantities on hot water, exhibits a beautiful experiment.

3 Take the size of a large pin's head of phosphorus, and wipe it upon blotting paper, then put it into the middle of a piece of dry cotton; hammer it, and it will set it on fire Paper, linen, &c. may be fired in the same manner

4 Put a little phosphorus into a small phial, melt the phosphorus, by putting the phial in warm water, and by rolling it about, it adheres to the sides of the phial, then cork it closely. When used, if a common match be introduced, it will take fire instantly (after pressing it into the fire-bottle,) when taken out.

206. If exposed to common air, or oxy-

gen gas when gently heated, it melts, takes fire, and burns, producing a bright white flame, with intense heat.

Observation. Its combination with oxygen gas, furnishes results different from all other combustibles, viz. phosphoric and phosphorus acid, also an oxide of phosphorus.

Experiment. Into a retort that will hold about a pint, put half a pint of water, and then add the size of a pea of phosphorus. Place it over a lamp, and when it gets warm, stars of fire, resembling sky-rockets, will be seen shooting about the water, in a most beautiful manner, and adhering to the sides of the retort. If the lamp is withdrawn, when the water boils, a curious appearance, resembling the *Aurora Borealis,* is seen at the surface of the water. If the heat is continued, a stream of light is seen to issue from the mouth of the retort, which again returns into the retort when taken away.

207. Phosphorus combines with oxygen at a lower temperature than most other substances, whence its great attractive power for this principle.

Example. Even the heat produced by friction is sufficient. Put a piece of phosphorus into a quill, and write with it on the wall of a dark room. The words thus written, will appear as if brilliantly illuminated. Care must be taken in this experiment to avoid touching the phosphorus with the bare fingers, as a burn from this substance is accompanied with more pain than any other.

208. By combustion, phosphorus attracts oxygen from the atmosphere, and becomes phosphorus acid.

Experiment. This acid may be made by a spontaneous and slow combustion of phosphorus. Arrange sticks of

phosphorus side by side, in a funnel placed in an empty bottle, the phosphorus will attract oxygen and moisture from the air, and trickle into the bottle in the state of liquid phosphorus acid. A degree of heat is sometimes excited, sufficient to inflame the phosphorus; to prevent this, let each stick be enclosed in a glass tube, a little longer than itself, and be covered with a glass dish, and, to afford moisture, let the whole stand in a plate of water. The acid produced, will weigh about three times as much as the phosphorus employed.

209. Phosphorus, in an uncombined state, when taken internally, is poisonous. Animals have been killed by merely drinking the water in which some newly made phosphorus had been washed.

MISCELLANEOUS EXPERIMENTS.

1. Mix one part of flowers of sulphur or brimstone, with eight parts of phosphorus, and dip a small piece of wood or match into the mixture. Rub the end of this match against a piece of cork or wood, and a flame will be immediately produced. In this way, the phosphoric match bottles, and German boxes are made.

2. Burn phosphorus in common air, it burns with brilliance, volumes of white smoke arise, condense these in a glass tumbler, moistened with water, and show, by rinsing it out with the infusion of litmus, that they are acid; the residuum is of an orange complexion, and is phosphorus united with a small portion of oxygen. Exposure to the air, converts it into phosphoric acid.

3. This experiment is more brilliant in oxygen gas. Burn some upon a dish in a jar containing oxygen gas, the air becomes diminished in quantity, and the phosphorus is converted to phosphoric acid, as it reddens vegetable blues.

4. Phosphoric acid may also be obtained by decomposing nitric acid, by means of phosphorus. If small pieces be thrown into a strong acid, the decomposition is dan-

gerous, attended with violent and beautiful flashes of light; if the acid be weak the decomposition is more gradual, and the phosphoric acid is produced in a manner you will, by this time, understand. The oxygen and phosphorus unite and the azot is set at liberty.

210. Phosphorus easily combines with sulphur. When the phosphorus exceeds the sulphur, it is called phosphoret of sulphur, and when the sulphur predominates, it is called sulphuret of phosphorus.

211. When the phosphoric acid is combined with any substance, it is then called a *phosphate*.

212. Phosphate of lime is the state in which phosphorus exists in bones, and from which it is extracted after they are calcined or burnt.

OF SULPHUR.

213. Sulphur or brimstone is found in most abundance combined with metals.

214. It is obtained by roasting or exposing metals to heat, when the sulphur flies upwards or is sublimed.

215. Sulphur also exists in vegetables, and it is emitted from animal substances, in a state of putrefaction, combined with hydrogen.

216. Sulphur has a strong attraction for oxygen, and burns upon the application of flame.

217. When heated sufficiently to take fire, it absorbs a certain portion of oxygen from the atmosphere, and is converted into *sulphurous* acid.

218. When burnt in oxygen gas, it absorbs a still greater proportion of oxygen, and becomes *sulphuric* acid.

219. Sulphur unites with the alkalies, potash and soda, forming hard substances of a brown colour, commonly called livers of sulphur, but more properly alkaline *sulphurets*.

Experiment 1. Sulphur unites with iron when melted. It is used for copying gems.

2. Sulphur, when fused and slowly cooled, chrystallizes.

3. Sulphur readily combines with the alkalies in the humid way, by mere boiling. The muriate of ammonia or sal amoniac and lime, boiled with sulphur, in a capsule, will combine with the lime, and render it soluble in water.

220. In this state, and combined with hydrogen, sulphur enters into the composition of the Harrowgate and other mineral waters, to which it gives a smell resembling that of rotten eggs.

Observation. Sulphur is a substance most useful in the arts: it is employed in the bleaching of stuffs, in the preparation of silks; it enters into the constituency of gunpowder; it furnishes sulphuric acid by combustion, and is often employed in manufactories. One might add, that by means of the sulphuric, we separate the nitric and muriatic acids from their combinations. Sulphur and sulphuric acids are therefore continually employed in chemistry, and very ofter in pharmacy.

EARTHS.

221. Earths are inflammable, inodorous, generally insipid, friable, and sparingly soluble in water. They are very refractory in the fire.

222. The names of the earths are as follows:

1. LIME.
2. ALUMINE or ARGIL, which is pure CLAY.
3. SILEX or pure FLINT.
4. MAGNESIA.
5. BARYTES.
6. STRONTITES.
7. ITTRIA.
8. GLUCINE.
9. ZIRCON.

223. Of these, Lime, Silex, and Alumine are the most abundant.

Observation. The earths have latterly been considered metallic oxides. On this subject professor Cooper remarks—"As to the introduction of the earths [and alkalies] among the metals, I have seen and made potassium too often, not to be aware of the metallic appearance of that substance—of its apparent emalgamation with mercury—of its attraction for oxygen, and the probability that caustic potash is the oxide of potassium. But these characters are not peculiar to these metalloids: the lustre of pyrites, and of the Chinese yellow orpiment, is as metallic and as brilliant as potassium. But for accuracy's sake let us settle what we

mean by a metal, before we call these substances metals. Hitherto the leading feature of a metal has been its weight; but the alkaline metalloids are the lightest of all solids.—Hitherto, the oxide of a metal has been deemed, without a contradictory instance, lighter than the metal itself; here it is heavier—Hitherto we have found every metal apt to combine, and form an alloy, with almost every other metal; in the present instance we can hardly yet say it has alloyed with any thing but mercury:—I am not prepared to deny any of the *facts* stated, but in an elementary work we should alter our definitions at least to suit the case." *Pref. to Thomson's Chem.*

224. Lime is generally combined with carbonic acid, in lime-stone, marble, and chalk, and is essential to the constitution of marls.

Example. If carbonate of lime be exposed to a strong heat, in a crucible, carbonic acid and water are disengaged, equal to 40 per cent. of its weight. The residuum is lime, or as it is called from its caustic and corrosive quality, *quick-lime.*

Observation. Quick-lime resists the action of high degrees of heat, though an excellent flux of the other earths.

Experiment 1. It is remarkable for its attraction for water. If boiling water be poured upon it in the dark, it exhibits a phosphorescent light.

2. Cold water, when sprinkled on it causes it to swell, heat, crack, and crumble to an impalpable powder. In this state it is termed slacked-lime.

3. 1000 ounces of lime are perfectly dry, after having absorbed 222 of water.

4. Slacked lime dissolves in water in the proportion of one to 600 parts by weight: hence lime-water is perfectly transparent, and even a brilliant fluid.

5. Lime-water possesses alkaline properties, for when poured into blue vegetable infusion they turn green.

6. Exposed to the atmosphere, lime attracts carbonic acid, increases in weight, and looses all its character as a simple and separate body.

7. Lime-water, mixed with mild alkali, in solution, robs the alkali of its carbonic acid, precipitates in a white powdery form, the alkali being left very pure.

225. The shells of oysters, lobsters, and other sea animals, as well as coral, and other marine productions, are chiefly composed of lime.

226. Lime is also the chief ingredient in the shells of eggs, and in those of snails.

227. Marl is only valued in proportion as it contains this earth.

228. The compounds containing lime already referred to, are chiefly such as also contain the carbonic acid; they are, therefore, the carbonates of lime.

229. Lime is obtained pure from limestone, &c. by the application of heat or caloric, or by burning, which drives off the carbonic acid. It is then called quick-lime.

230. Lime, after being burnt, has a strong attraction or affinity for water, and when it has imbibed a proper quantity of this fluid, it is called *slacked* lime.

Observation. The heat which is yielded during this operation, is derived from the water; not the lime. It is the heat of liquidity rendered perceptible during the action of slacking; for lime, properly slacked, is perfectly dry, the water is therefore in a concrete state, at least such portion as remains combined with the lime.

231. Lime unites with other acids. *Plaster of Paris*, or gypsum, is a combination of lime and the sulphuric acid.

Observation. This compound, though used in husbandry, is very different in its action from the lime stone preparations already alluded to, for *burning* does not banish its acid; yet, by depriving it of its constituent portion of water of chrystalization, it becomes pulverulent, and very energetic upon certain grounds.

232. *Alumine* is a peculiar earth, found most abundant in *alum*, whence its characteristic name.

233. It abounds in all clays and argillaceous earth. It gives a laminated texture to the fossils in which it abounds.

Observation. When pure, it is a fine white powder, smooth and soapy to the touch, adhering to the tongue. Alumine constitutes a large portion of the potter's and fuller's earth. It enters into the combination of the ruby and sapphire. It is employed in making the pyrometer of WEDGWOOD, in porcelain, and in the construction of furnaces, and especially in the manufacture of bricks and tiles. It is never found pure, though very abundant in the globe.

234. *Clays* are found generally moist, in their natural state, on account of the great attraction of alumine for water.

Observation. It is this circumstance which constitutes alumine the basis of the art of pottery; an art which has been brought to a high state of perfection in England, by the labours of one enlightened individual, Mr. Wedgwood.

235. *Clay*, when diffused, and wrought into a paste with *water*, is highly ductile

and plastic. On being exposed to intense degrees of heat, it becomes impenetrable to it.

Observation. Crucibles, retorts, glass-house pots, stone-ware, queen's ware, &c. refer to alumine as their necessary basis.

236. *Silex*, or the earth of flints, is most abundantly found in that fossil. It scintilates with steel, which is a distinguishing property, dependent upon its extreme hardness.

Observation. It cuts glass like diamond. It is nearly pure in the whitest sand, as that from *Lynn*, in Norfolk. The fluoric acid is its proper menstrum: it fuses also into a glass, with the boracic and phosphoric acids. It is essential in the manufacture of glass, pastes, and factitious gems.

237. Free-stone and gravel contain silex, but almost always united to foreign matter, and in England, often to iron.

238. The stones so much admired under the name of pebbles, are also compounds of silex and other matters.

Observation. These are wrought by the lapidary into various trinkets, seals, &c. much esteemed for their hardness and variegated tints, or grotesque fractures when polished. There is an Egyptian pebble, at the British Museum, which, being accidentally fractured, exhibited a very correct likeness of the celebrated and earliest British poet, Jeffery Chaucer, as appears by comparing it with an old painting on pannel, also in the collection. Scotch pebbles are also much admired. The agate is of this order.

239. Porphyry, granite, whinstone, and

basaltes, which last composes the celebrated giant's causeway in Ireland, and Fingal's cave in the island of Staffa, have the silicious earth for their basis.

Observation. It is besides contained in quartz, and the business of the enameller depends greatly on its employment. Under particular circumstances, it becomes soluble even in water. This is known to those who have visited the *Geysers* or hot springs of Iceland. *Chalcedony* or white agate is the natural deposit of silex from its aqueous solution. It is found in the ashes of most plants, and in the interior coating of the common cane, used for walking sticks, many of which are said to strike fire with steel.

240. The common black gun-flint belongs to silicious stones, and is always found in beds of chalk and lime-stone.

241. Rock chrystal exhibits silex in its purest natural state.

Observation. Silex has the property of combining with fluor spar, and forming a compound, which, though not sour, has by some modern writers been termed silicated fluoric acid. "Let us alter our definitions," says Professor Cooper, "and I will agree that silex is an acid; but while people will persuade themselves that acids are sour to the taste, they will not understand the mystery of calling a piece of flint an acid."

242. Magnesia is never found pure in nature, but is generally procured from the sulphate of magnesia (Epsom salt) which exists in mineral springs.

243. The mineral springs of Epsom formerly supplied the greater part of what was used in commerce, from whence it derived its name.

Observation. The substances *talc*, *asbestos*, *amianthus*, and *steatites*, are fossils which contain it *Magnesia alba*, of the shops, is its *carbonate*, while pure magnesia is generally but improperly distinguished by the term calcined.

Example 1 If we decompose the sulphate of magnesia by adding the carbonate of potash, both in solution, we obtain the carbonate of magnesia.

2. If we expose the carbonate of magnesia to a high heat, in a crucible, we shall obtain pure magnesia.

Illustration For when exposed at a red heat, it becomes deprived of its carbonic acid, and leaves behind the white, tasteless, and nearly insoluble earth, *magnesia.*

Observation It is chiefly used in medicine as an antidote to acids, when the stomach by indigestion is suffering from such crudities.

244. *Barytes* has its name from its weight, it is the heaviest of the earths. It is acrid, caustic, and possesses alkaline qualities.

Observation. It is more soluble than the other earths, and possesses a greater affinity for acids. with which it is found naturally always combined. In medicine it can only be exhibited in a small quantity, on account of its poisonous quality. It has been employed as a powder for killing *rats*

Example Pure barytes is soluble in water, and is a test of the presence of sulphuric acid, to which, when its aqueous solution is added, a ponderous substance, in the form of an impalpable powder, is precipitated.

245. *Strontites*, another earth, so named from the place in Scotland, where it was found to exist in abundance.

246. When pure, it is very like the last in appearance, and has a bitter taste. No substance in nature, but this, tinges flame of a

carmine colour. The chrystals of its salts differ from those of barytes. They are also more soluble.

Experiment 1. Dissolve a little of the muriate of strontites: add alcohol, kindle it, and beautiful red flames ascend

2. Or put a little of the salt upon a candle, and the carmine flame is instantly produced.

Example. Strontites is further remarkable for the brilliancy of the flame it exhibits when heated at the blowpipe

Observation. It possesses, like the other earths, tenacity, fixity in fire, sparing solubility, freedom from odour, and does not give a tinge to glass. Of the earths, it must be admitted, that those most generally useful, are lime, alumine, silex, magnesia, and barytes.

247. *Ittria* is an earth recently discovered in Sweden. It is characterised by the general properties of the other earths, differing in some few particulars.

248. *Glucine* is a constituent of some precious stones. The emerald and beryl yield it.

Experiment. Its sulphate in solution, is remarkable for giving a yellow precipitate when added to the infusion of the gall-nut.

249. *Zircon* is found in the hyacinth of Ceylon.

Observation. It differs from silex and alumine, in being soluble in the fixed alkalies.

OF THE ALKALIES.

250. The alkalies have a bitter and somewhat burning taste.

251. They change the blue juices of vegetables, such as that of red cabbage, to a green.

252. When combined with oil and water, they render these two substances capable of being mixed, or intimately blended with each other.

253. The two fixed alkalies, or those which cannot be evaporated or changed, without being made red-hot, are called *potash* and *soda*.

254. The third alkali is called *ammonia*, and it is also known by the name of the *volatile* alkali, because it becomes volatile or evaporated at the temperature of the atmosphere.

255. The alkalies have hitherto been regarded as simple substances, but Mr. Davy, of the Royal Institution, has recently attempted to prove them composed of peculiar metals.

Observation. On this subject, see extract from Professor Cooper, page 76.

256. *Potash* is procured from the ashes of burnt wood, or other vegetables: hence it is called the vegetable alkali.

257. It is also found in earths, and in the ores of metals, and it is imbibed by plants from the earth, while they are growing.

258. *Alkalies* have a stronger affinity with acids than metals, so that, generally speak-

ing, they will precipitate them from their acid menstruums.

Experiment. Oxymuriate of mercury in solution, has the oxide of that metal, which is its base, precipitated of a bright brown colour, by the addition of *potush.*

259. *Soda* is procured by burning sea-plants, or sea-weeds, as they are sometimes called: hence it is called the mineral alkali.

260. Soda is the constituent principle in sea-salt, used at table, the chemical name of which is muriate of soda.

261. Soda is found in the natron beds of Egypt, as also in Syria, and in India, in large quantities, combined with carbonic acid.

262. The uses to which potash and soda are applied, are nearly similar.

Illustration. They are used to melt along with silex, or pounded flint, in the formation of glass. In dyeing they are found to be of service in changing some vegetable colours, and in making others brighter. They are also used in washing and bleaching linen. When combined with oil or tallow, they form soap; the greasy substance, when mixed with them, prevents them from burning or corroding the hands, which they would do in their separate state.

263. The potash of commerce is principally obtained from Russia and America.

264. In the north of Scotland different kinds of sea-weed are employed, and furnish by a very rude process, an impure alkali named Kelp. The saline matter obtained from the same weeds in France and Spain,

is termed barilla, and contains much more alkali than the kelp.

265. Potash and soda may be obtained sufficiently pure for most chemical purposes, by mixing a strong solution of either of them with a quantity of quick-lime. The lime having a stronger affinity for the carbonic acid, with which the fixed alkalies is generally combined, unites to it and forms a carbonate of lime, which is precipitated, while the potash or soda is held in solution, and may, by filtration, be separated from it, and afterwards evaporated to dryness.

266. When potash and soda are purified from foreign substances, they are called caustic alkalies, and in this state if applied to the skin will almost instantly destroy it.

267. Potash and soda are generally used in combination with carbonic acid. They are then carbonates, and from their corrosive properties being neutralized, are termed mild alkalies.

268. Ammonia or volatile alkali has a strong and very pungent smell. It is caustic, but does not corrode animal matter like potash and soda.

269. Its most simple state is that of ammoniacal gas, or vapour, which is lighter than atmospheric air, but not so light as hydrogen gas.

Ex. 1. To procure ammoniacal gas, mix one ounce of pounded sal ammoniac, with two ounces of quick-lime: put the mixture into a Florence flask, and apply a lighted lamp or candle to the bottom, and ammoniacal gas will rise in abundance.

2. Dissolve some sal ammoniac in water, and then heat the solution as above, when ammoniacal gas will also rise from the liquid ammonia.

270. *Ammonia* is composed of two parts of hydrogen, to one of nitrogen or azote.

271. All animal and vegetable substances furnish ammonia when in a state of putrefaction.

272. It is procured in England by distilling or burning bones, horns, and other animal substances, hence sal ammoniac is sometimes called hartshorn.

273. Sal ammonia, or muriate of ammonia, is formed by combining ammoniacal gas with the substance called muriatic acid gas.

274. Sal ammonia is used by dyers to give brightness to certain colours, and by braziers, tin-plate workers, &c. in scowering the surface of other metals, previous to their being plated or tinned.

OF THE ACIDS.

275. The acids are substances which produce the taste of sourness, when applied to the tongue.

276. Acids change the blue juices of vegetables to a red.

277. They combine with alkalies, earths, or metallic oxides, and form the compounds called salts.

278. They owe their origin to the combination of oxygen, or the acidifying principle, with certain substances.

279. This class of bodies has been sometimes divided into mineral, vegetable and animal acids, according to the substances from which they were supposed to be extracted. But as the same acid is sometimes found to exist in each of the kingdoms, a different mode of classification has been adopted: the composition and nature of the acid, when it will admit of it, being pointed out, instead of the class of bodies from which it is extracted. Thus sulphuric acid is so called because it is composed of sulphur and oxygen—Carbonic acid because composed of carbon and oxygen, &c.

280. In cases where the acid has a compound base from which the name could not readily be derived, it is then generally taken from the substance of which it is principally formed; as the gallic acid, from galls; the camphoric acid, from camphor, &c.

281. Acids arise either from combustion or oxidation, and such bodies as form acids during these operations, are denominated acidifiable bases.

Observation 1. If an acidifiable basis be perfectlysa-

turated with oxygen, the acid, thus produced, is said to be perfect; but if the *basis* predominate, the acid is said to be imperfect.

2. Modern chemists distinguish the first state by the syllable *ic*, and the latter by *ous*. Thus we have the sulphuric and the sulphurous acids, the phosphoric and phosphorous acids. Finally, if oxygen be combined with the acidifiable basis in so small a proportion that the compound body does not indicate any acid property, it is simply called an *oxide*.

282. *Sulphuric acid*, or oil of vitriol, is procured by burning sulphur, in contact with oxygen.

283. The sulphuric acid is a very heavy and corrosive liquid. It is destitute of colour or smell, but has a very acid taste.

284. When sulphuric acid is united with earths, metals, or alkalies, they are called *sulphates*.

Illustration. Lime, when dissolved in this acid, is sulphate of lime. Iron, in the same state, is called sulphate of iron, and potash or soda, treated in a similar way, become sulphates of potash, &c.

285. The sulphuric acid, in the state of gas, has a strong suffocating smell, but it is easily absorbed by water, and then forms liquid sulphurous or sulphuric acid.

286. *Muriatic acid* is obtained by distillation from sea salt.

287. In the state of gas, in which it is procured, it has a pungent suffocating smell, but is easily absorbed by water, when it becomes liquid muriatic acid.

288. Muriatic acid has not as yet been decomposed, and it is therefore considered by some chemists, as a simple substance.

Observation. Muriatic acid has been considered by many chemists a simple substance: but from the late experiments of professor Davy, he has pronounced it a compound of hydrogen and oxymuriatic acid. Further experiments however are necessary to fully establish the fact.

289. When united with various substances, it forms the salts called *muriates*.

Illustration Common table-salt is called muriate of soda, because when decomposed, it is found to consist of soda and muriatic acid. By similar combinations, muriates of lime, &c. are formed.

290. By the addition of oxygen to the muriatic acid, it forms oxymuriatic acid.

Observation 1. Professor Davy differs from the common opinion respecting oxymuriatic acid He contends that it is a simple body, which, from its green colour, he terms Chlorine: that in the process for obtaining this chlorine from muriatic acid, hydrogen is disengaged; which combining with oxygen, liberated from the metallic oxide used in the process, forms water; and that in the re-formation of muriatic acid, the oxygen which is driven off arises from the decomposition of water that is, as he supposes, always present; the hydrogen of which unites to the chlorine, and forms muriatic acid.

2 This ingenious hypothesis appears to explain many of the operations in which oxymuriatic acid is produced. But there are a few exceptions so striking, that they render professor Davy's theory inadmissible, and justify the former opinion, viz. That his chlorine is muriatic acid, combined with oxygen.

3. The following experiment of Murray is to the point. He mixed "equal measures of carbonic oxide and

hydrogen gases, with two measures and a half of oxymuriatic acid gas, each previously dried, exposing the mixture to light; after 24 hours, the peculiar colour of the oxymuriatic acid gas had disappeared, more than half the gas was instantly absorbed by water, and was muriatic acid gas; and the residuary gas copiously precipitated lime-water, and was carbonic acid gas."

4. If, in this experiment the oxymuriatic acid gas had been, as contended for by Davy, a simple substance uncombined with oxygen, neither the water nor the carbonic acid gas which resulted from the process, could have been formed; for the carbonic oxide and hydrogen could only become changed by the addition of oxygen, and no substance in the mixture could have afforded it except it was found in the oxymuriatic acid.

291. The gas produced from oxymuriatic acid is so suffocating, that it cannot be breathed without great injury.

292. Oxymuriatic acid discharges or takes out vegetable colours.

Observation 1. This extraordinary property of the oxymuriatic acid, either in the gaseous form, or when combined with water, has led to its application in the art of bleaching. The cloth to be whitened is to be prepared first by steeping it in warm water for some hours, in order to take up such part of the colouring matter as may be soluble. It is then boiled in alkaline ley prepared from twenty parts of water and one of potash, rendered more active by having been mixed with 1-3d of lime. After sufficient boiling it is washed with water, and put into close wooden troughs, containing the oxymuriatic acid united with water; in which it is allowed to steep for three or four hours, pressing the cloth frequently, and exposing its surface to the action of the liquor.

2. It is thus alternately exposed to the action of the alkaline ley, and the oxymuriatic acid, till its colouring matter is completely extracted, or until it is sufficiently bleached; which requires in general from eight to ten

immersions, according to the nature and coarseness of the cloth; cotton requiring fewer immersions than linen. After this process, the linen or cotton is rubbed strongly with soft soap in warm water: this renders the surface more smooth and uniform, and takes away the smell of oxymuriatic acid. The cloth is again washed; and lastly, is immersed for a short time in water, in which from a 60th to a 100th part of sulphuric acid has been dissolved. The cloth, by this means, acquires a much finer whiteness, from the sulphuric acid dissolving any possible remains of colouring matter, as well as a small quantity of iron and calcareous earth, contained in all vegetable substances, or even deposited in the cloths from the alkaline leys.

3. The great difficulty which attended the use of the oxymuriatic acid in whitening of linen, arose from the suffocating odour, which rendered it extremely difficult to work with it in open vessels. But it was discovered, that an alkali in a great measure removed this odour, or at least prevented its injurious effects: And an improvement, by Tennant of Glasgow, has not only removed this difficulty, but has put it in the power of every manufacturer to avail himself of the benefits arising from the use of this very valuable substance. He found, (and obtained a patent for the discovery), that the oxymuriatic acid was capable of combining with dry lime; and that by dissolving a certain proportion of this compound in water, it formed the bleaching liquor, dispossessed of its suffocating odour.

4. The advantages of this discovery have been very important; the compound can be now carried easily to a distance, and the manufacturer need not prepare it himself.

5. The combination is formed by introducing the oxymuriatic gas through leaden tubes, into *slacked* lime prepared from chalk, by which it is absorbed. Solutions of this are prepared by the manufacturer, of different strengths, according to the purpose to which they are to be applied; the strength being ascertained by the hydrometer, and by the quantity necessary to destroy

the colour of a diluted solution of indigo in sulphuric acid.

6. The common mode of procuring the oxymuriatic acid for bleaching is to mix 2·7th parts of the muriate of soda with one of manganese; to which three parts of sulphuric acid is added, diluted with two of water; to which a moderate heat is applied.

Experiment. When candles are made to burn in the oxygenized muriatic acid, they yield a reddish flame.

Observation 1. Thus it should seem, that though incapable of being breathed with impunity, animal and vegetable colours, putrid and contagious effluvia, and actual inflammation or combustion are affected by the oxymuriatic acid.

2. Its salts are decomposed, unless cautiously evaporated in the absence of light.

3. The French chemists first discovered that this acid gas was of the highest importance, not only in chemistry, but as a medicinal agent, from its antiseptic powers, and its correcting vapours, and destroying the fœtor of places of which the soil is corrupted, as well as the air, which may be infected with septic *miasmata.*

4. It may be added, therefore, that at the same time it destroys colour, it neutralizes scents, though itself possessed of what appears to the major part of experimentors the most intolerable.

5. The virus of various poisons is rendered completely inert by the powers of the oxymuriatic acid. This part of its uses has not been carried to the extent it deserves by medical artists, though the philosophical chemist knows of no truth more certain, than that such are its powers.

Example. By exposing its solution to intense cold, the oxymuriatic acid chrystallizes in plates.

293. The gas obtained from this acid, oxidizes and burns several of the metals without the assistance of heat.

Ex. 1. To obtain oxymuriatic acid gas, procure some manganese in powder, and pour upon it double its weight

of muriatic acid; pour the mixture into the phial or retort, described in the apparatus, for obtaining oxygen gas. Connect the phial, by means of a tube, with the receiver on the shelf of the tube. The gas will immediately rise into the receiver, and if the heat of a lamp be applied to the bottom of the retort, containing the manganese and muriatic acid, the gas will be sent off in greater abundance.

2. If the receiver, into which the oxymuriatic acid gas rises, be provided with an orifice and stopper at the top, introduce into the gas a piece of Dutch metal, or copper foil, it will instantly take fire, and will burn until the whole will be consumed, affording a very curious spectacle.

3. Throw some bits of gold leaf, or some zinc, in powder, into a receiver, filled with this gas, and showers of fire will be produced, of very brilliant appearance.

294. *Nitric acid*, (or aqua-fortis) is one of the constituent parts of nitre, or saltpetre. It is itself composed of oxygen and nitrogen.

295. Nitric acid is clear and colourless, like water; its smell is pungent, its taste exceedingly acid, its action on animal substances is corrosive, and it stains the skin yellow.

296. Nitric acid oxidises, or dissolves most of the metals, and when united with them and other substances, forms the salts called *nitrates*.

297. *Nitro-muriatic acid* (or aqua regia), is formed of two parts of nitric acid, to one of muriatic acid. It is the only acid which dissolves gold.

298. *Carbonic acid* is a combination of

carbon and oxygen. It is found in chalk, lime-stone, magnesia, &c.

299. In the form of gas it unites slowly with water; but by the assistance of agitation and pressure, the water may be impregnated with it in a very high degree, by which means it acquires an agreeable acidulous taste.

Illustration. Carbonic acid gas is found in many natural waters. Those of Prymont and Seltzer in Europe, and the Balls-town springs in the state of New-York, are highly impregnated with it. The artificial mineral waters of Philadelphia are composed of common water and carbonic acid gas, with the addition of such salts as are found in the waters composing the different springs which are intended to be imitated.

300. Carbonic acid enters into combination with the alkalies, earths, and metallic oxides.

301. When combined with metals, they are then called *carbonates.*

302. *Phosphoric acid* is compounded of phosphorus and oxygen. It is procured chiefly from bones, by distillation. The earthy substance, which remains after the oil and jelly they contain is separated from them, is phosphoric acid, mixed with lime.

303. Phosphoric acid, when deprived of water, is solid and transparent, when liquid it is of a thick oily appearance.

304. *Fluoric acid* is found in Derbyshire or *fluor* spar, which is compounded of fluoric acid and lime.

305. Fluoric acid has the property of dissolving glass, and is used for the purpose of engraving or etching on that substance.

Ex. 1. To obtain fluoric acid, pound some Derbyshire spar, and pour over it an equal quantity of sulphuric acid. A gas will be immediately liberated, which may be received into a vessel, containing a small quantity of water; the water will absorb the gas as it rises, and fluoric acid will be the consequence. The vessels used in this experiment, should be of lead, as the glass apparatus, formerly described, would soon be corroded or dissolved by the acid.

2. If the glass apparatus is used in obtaining fluoric acid and no water is put into the receiver, the following amusing experiment may be made. Put a dead fly, or other small animal, into the receiver, into which the gas rises; in a few minutes the natural moisture will absorb fluoric acid; the silex contained in the glass, will be dissolved and precipitated upon the animal, which will then be a petrefaction, or an animal covered with stone.

3. Cover a piece of glass with a thin coating of wax, and then trace a drawing of any description, with a proper instrument, through the wax into the glass. Put this piece of glass into the receiver of an apparatus of lead, and apply the gas of the fluoric acid as above described, when the part of the glass exposed to it, will be corroded so as to exhibit every feature of the drawing.

306. *Boracic acid* is composed of the substance called borax and oxygen. Its properties are little known, and it is not much in use.

307. Arsenic acid, tungstic acid, molybdic acid, and chromic acid, are combinations with various metallic oxides, but their properties have not as yet been clearly ascertained.

308. *Acetous acid*, or vinegar, is obtained by exposing liquors, such as wine, malt-liquors, &c. which have undergone fermentation, to the open air. By this means they imbibe oxygen, or the acidifying principle.

309. Acetous acid, as usually prepared, is a yellowish liquid. When it is distilled it is as clear as water, and more acid; it is then known by the name of distilled vinegar.

310. *Acetic acid* is merely acetous acid, brought to a higher degree of acidity, or concentration.

311. Acetic acid enters into combination with the alkalies and metals, and forms, with them, the substance called *acetates*.

Illustration. In chemistry, the acetates of copper, of lead, of soda, and of potash, are compounds of this description.

312. Acetic acid, when highly concentrated, is pungent and acrid, and corrodes animal substances.

313. *Oxalic acid* is found in abundance in the juice of sorrel, from which it derives its name. When pure it is then in the form of small white chrystals, of an agreeable taste. It may also be artificially procured from sugar and the nitric acid.

Experiment. In the distillation of sugar with the nitric acid, the peculiar acid of sugar, or the oxalic acid, is separated.

314. Oxalic acid also exists in chickpease, sugar, and other vegetable substances, and is also found in great abundance in wool.

315. Oxalic acid is used by the calico-printers, in dissolving the metallic oxides, as well as other substances, for the sake of colours.

316. It is also used for taking out iron moulds from linen, which it is enabled to do, by its dissolving the iron.

317. *Tartarous acid.* The cream of tartar in the shops, is composed of the tartarous acid and potash. When this acid is obtained pure, it appears like the last, in the form of white chrystals.

318. The cream of tartar is obtained in all vessels where wine has been kept, and especially port-wine.

Experiment 1. The tartarous acid is procured by mixing the tartar with chalk, or lime, which imbibes the superfluous acid.

2. Or it may be procured by boiling the tartar with five or six times its weight of water, and then adding to it the sulphuric acid. This unites with the vegetable alkali, and forms vitriolated tartar, or (properly speaking) the sulphate of potash ; and the pure acid of tartar may be obtained in chrystals by evaporation and filtration, equal in weight to half the cream of tartar employed. This acid of tartar is more soluble in water than the cream of tartar.

319. *Citric acid*, or lemon juice, is found in the juice of lemons, and several other fruits. It is used in medicine to counteract the effects of opium, and similar poisons.

Illustration. If a person who has taken opium or laudanum, be made to swallow large quantities of lemon-juice, until vomiting is produced, the deadly effects of the poison will entirely cease.

Experiment. Buffs, and other colours, are discharged by the citric acid, upon which principle it is, that calicoes, with a dark ground, have white stars, or other ornaments, formed upon them, by means of proper blocks, charged with citric acid, and printed after the usual manner. This effect is termed discharging

320. *Malic acid* is obtained from the juice of apples, strawberries, and other fruits. It is a reddish coloured, and very sour fluid.

321. Malic acid is only used in chemistry, by way of a test, or in order to discover the presence of certain substances, or to separate two substances that are closely combined with each other.

Illustration. The two simple earths, alumine and magnesia, are generally found minutely combined with each other. Pour some malic acid upon this substance, and the alumine will unite with the acid, and fall to the bottom, or be precipated. The magnesia will then remain suspended or dissolved in the remaining fluid, and in this state it is called *malate* of magnesia.

322. *Lactic acid* is procured from milk. It is in fact the whey of milk, when become sour.

323. *Gallic acid* is found in the galls, used in commerce, in oak-bark, and other vegetables.

324. Gallic acid has the property of precipitating iron of a black colour, when iron is dissolved by any of the acids, for which reason it is employed in making ink.

Illustration. Common writing ink is made by mixing galls soaked in water, or an infusion of galls with copperas, which is a sulphate of iron.—Copperas which has been exposed to the air is always composed of a green and a red sulphate The last of these is formed from the green sulphate, by the metal receiving a higher degree of oxidation by exposure to the air. And it is this red sulphate combined with the gallic acid, that forms common writing ink, or a gallate of iron.

325. *Mucous* or *saccholactic acid*, is obtained from gum arabic, or other mucilaginous substances. It has not been as yet applied to any useful purpose.

326. *Benzoic acid* is prepared from the substance called Benzoin, or gum Benjamin. This acid is used in medicine by the name of flowers of Benjamin.

327. *Succinic acid* is prepared from amber, a transparent combustible substance dug out of the earth, which is used for making beads, and other ornaments.

Illustration. Succinic acid is obtained by putting equal parts of dry sand, and powdered amber, into a stone or metal retort, and making it red-hot, the acid then rises into the neck of the retort, in the form of shining white chrystals.

328. *Camphoric acid* is obtained from camphor, a white crystalline substance, obtained in the East Indies, from a kind of laurel tree.

329. *Prussic acid* is composed of hydrogen, nitrogen, and carbon. It is a colourless liquid, like water, and has a sweet taste.

330. It is prepared from blood, and other animal substances, and when united with iron, it forms the colouring substance called Prussian blue, used in dyeing.

331. *Sebaccic acid* is procured from animal fat, or tallow. It has an acid, sharp, and bitterish taste.

OF SALTS.

332. When an acid is combined with an alkali, an earth, or a metallic oxide, it forms what is called a salt.

333. When the quantities of the acid, and of the other substance are equal, the combination is called a *neutral* salt.

334. All salts, which are compounds of metallic oxides, earths, or alkalies, with the sulphuric acid, are called *sulphates*.

335. When the muriatic acid is in combination with an earth, an alkali, or a metallic oxide, the compound is called a *muriate*.

336. When the same thing happens with the nitric acid, the compounds are called *nitrates*.

337. Carbonic acid, combined with earths, alkalies, or metals, forms *carbonates*.

Illustration 1. The saline compound, commonly known by the name of Glauber's salts, is sulphate of soda, being a combination of sulphuric acid and soda.

2. Plaster of Paris, or gypsum, is called sulphate of lime, from being composed of sulphuric acid, and lime.

3. Green copperas is sulphate of iron, being compounded of sulphuric acid and iron; not of copper, as formerly supposed.

4. Common salt is *muriate* of soda, being composed of muriatic acid and soda.

5. Salt-petre is nitrate of potash, being composed of potash and nitric acid.

6. Chalk is carbonate of lime, from being formed of carbonic acid and lime.

338. When a salt is found to contain more of the acid than of the other substance combined with it, the word *super* is affixed to it.

Illustration. When chalk has more carbonic acid than lime, in its combination, it is called *super-carbonate* of lime.

339. When the alkali, earth, or metal, combined with an acid; exceeds the acid in quantity, the word *sub* is affixed to it.

Illustration. If the sulphuric acid is less than the iron in sulphate of iron, it is called subsulphate of iron.

Observation 1. Another variety of salts is produced by the union of an acid with two bases, which are called triple salts, and take the name of both bases, as prussiate of potash and iron, tartrate of potash and soda, &c.

2. Those metallic salts, the bases of which contain an excess of oxygen, are distinguished by the abbreviation *oxy*, as oxysulphate of iron. The same adjunct is also used when the acid of salt contains an excess of oxygen, as oxymuriate of potash.

340. All salts, composed of acids, ending in *ous*, take a termination in *ite*, instead of *ate*.

Illustration. Lime, combined with *phosphorous* acid, is called *phosphite* of lime, whereas, when combined with the stronger or phosphoric acid, it is called *phosphate* of lime.

341. The *sulphates* have a bitter taste: those which are most familiar, are the sulphate of lime, or plaster of Paris, and the sulphate of alumine or alum.

Illustration 1. Sulphate of lime is found in abundance in Staffordshire, Derbyshire, and many other places of England. The hills around Paris are almost entirely composed of it, hence it is called plaster of Paris. When burnt or calcined, and pounded, it may be mixed with water, for which it has so great an affinity, that it becomes solid almost immediately. It is therefore used in making busts, cornices, &c.

2. Sulphate of alumine or alum. It is found in pits in great abundance, near Glasgow, in Scotland, and at Whitby in England. It is found mixed with earths, which are precipitated from it, by water being added in abundance. The alum is dissolved by the water, and the solution being drained off from the earthy matter, soon chrystallizes or concretes into what is called rock alum.

242. The *sulphites*, or sulphurous salts, have always a disagreeable sulphurous taste; when exposed to fire they yield sulphur, and become sulphates.

343. The sulphites are seldom applied in chemistry, or the arts, to any useful purpose.

344. The *muriates*, when mixed with strong sulphuric acid, yield muriatic acid in the form of a visible vapour: when nitric

acid is poured upon them, they yield oxymuriatic acid gas.

Ex. 1. Put a handful of common salt (muriate of soda,) into the glass bottle or retort of the pneumatic apparatus: drop gently into it some strong or concentrated sulphuric acid: fix the retort to the receiver, and a thick white vapour will be seen to rise from the mixture This is muriatic acid, and if a little water is introduced into the receiver, previous to the operation, the water will be impregnated with the acid, and form a liquid muriatic acid.

2. If nitric acid be used instead of the sulphuric acid, oxymuriatic gas will be formed.

345. The muriates are the most volatile and yet the least decomposable by fire, of all the salts.

Illustration. Put some common salt into an earthen retort, and having fixed a receiver to it, make the retort red-hot, by inserting it into a strong fire. The salt will be volatilized, that is, it will rise into the receiver, but it will still be unaltered, and will still remain common salt.

346. The chief muriatic salts are the muriates of potash, of soda, (common salt), of lime, and of ammonia, (sal ammoniac).

Observation 1. Muriate of barytes is used as a test of the presence of sulphuric acid. It is poisonous even in small quantities. It is also used in the preparation of pure muriatic acid.

2. Muriate of soda has great uses in the arts, &c. as furnishing to chemistry both the muriatic acid, and soda. Its uses as a preservative are well known.

347. The *nitrates* are remarkable for yielding oxygen gas, mingled with nitrogen gas, when heat is applied to them.

348. When concentrated sulphuric acid is poured upon them, they yield nitric acid, in white vapours.

349. The nitrate which is most familiar to us is nitrate of potash, commonly called nitre, or salt-petre.

350. The *carbonates* are known by giving out carbonic acid, when the sulphuric or nitric acid is poured upon them.

351. Carbonate of lime, or common chalk, is the most common of these salts.

352. The phosphates may be melted either into an opaque, or into transparent substances called glass of phosphorus.

353. The most common phosphoric salts, are phosphate of lime, a white tasteless substance, which is found in a native state in many parts of the world.

354. Phosphate of lime is found in bones, milk, and several other animal matters: it is also abundant in wheat.

355. The *fluates* are remarkable for forming the fluoric acid, which corrodes or dissolves silex.

356. The most common are fluates of lime, of soda, of ammonia, of alumine, and of silex.

357. The fluate of lime enters into the composition of Derbyshire spar. It also exists in the human teeth, forming the enamel, which defends them from decay.

358. The *acetates* are the combinations of certain substances, with the acetic acid. They are distinguished from most other salts, by being easily dissolved in water.

359. The chief acetic salts, are the acetates of barytes, of potash, of soda, of lime, of ammonia, and of magnesia.

360. The acetate, with which we are most familiar, is acetate of lead, or sugar of lead.

Illustration. To make acetate of lead, procure some common white-lead, and dissolve it in acetous acid, (distilled vinegar): apply heat to the solution, and the water of the acetous acid will fly off in vapour, leaving acetate of lead in the form of minute chrystals.

361. The *tartrates* are combinations of substances with tartaric acid. The tartrate of lime is most common, and it is found in the common tartar used in commerce.

362. The *prussiates* are formed by combinations of the prussic acid, with potash and soda. These are called alkaline prussiates.

363. There are also *triple prussiates*, which are best known from being used in dyeing, by the name of Prussian blue.

364. The triple prussiates are composed of Prussic acid and iron, combined with potash, soda, lime, or ammonia.

OF OXIDES.

365. The simple substances, when united to a less quantity of oxygen than is necessary to form *acids*, are called *oxides*.

366. Metals, earths, and vegetables, furnish substances which may be converted into oxides, by a union with oxygen.

367. Most of the metals become oxides by exposure to the atmospheric air. They also take oxygen by lying in water, or in the acids, both of which substances are decomposed or robbed of their oxygen, by their union with metals.

Illustration 1. Gold, silver, and platina, are not oxidized or rusted in the open air, but they become so when an acid is applied to them, or when highly heated, because their particles are then expanded, and can more readily admit of the oxygen.

2. Iron, copper, and lead, become oxidized upon exposure to the air for a few days. Manganese will become a perfect oxide after being a few hours in the open air.

368. The metals have different degrees of affinity for oxygen; some being more easily oxidized than others, will reduce an oxide to its metallic form, when brought into contact with it.

Illustration 1. Zinc, by its powerful attraction for oxygen, decomposes a great number of salts and metallic solutions, and precipitates the metal from them, either in a metallic form, or less oxidized than they were before.

2. Upon this principle, the pin manufacturers whiten their pins. They fill a pan with alternate layers of pins and grain tin, upon which they pour a solution of tartrit of potash, (tartarous acid and potash) and boil the whole four or five hours. The tartaric acid dissolves the tin, and gradually deposits it on the surface of the pins, in consequence of its greater affinity for zinc, which enters into the brass wire, of which the pins are made.

369. Metallic oxides are generally in powder; with the acids they form the metallic salts, and they are heavier than the primitive metal.

370. No metal is capable of being dissolved in the acid until it is combined with a specific degree of oxygen.

Illustration. If a metal has more than the specific degree of oxygen, it will fall to the bottom in a solution, instead of being dissolved, and forming a metallic salt.

371. Sulphur, phosphorus, hydrogen, carbon, and nitrogen, have their oxides, as well as the metals.

372. Sulphur becomes oxide of sulphur, by being kept in a melted state in the open air until it becomes of a red colour. With a greater portion of oxygen, it becomes sulphuric acid.

373. Phosphorus, when exposed to a small portion of air, becomes first white, and then dark brown. In this state it is oxide of phosphorus; with a greater quantity of oxygen, it is phosphoric acid.

374. Hydrogen enters into combination with oxygen in one degree only, and forms

water, which is strictly speaking, an oxide of hydrogen.

375. Nitrogen, and a certain portion of oxygen, forms *nitrous oxide*, a further portion makes it *nitric oxide*.

376. *Nitrous oxide* is procured by exposing nitrate of ammonia in a retort, to the heat of a lamp, until red-hot. The oxide then rises in the form of gas.

377. Nitrous oxide supports combustion better than atmospheric air. When breathed into the lungs, it communicates a pleasurable or intoxicating sensation.

378. *Nitric oxide*, or nitrous gas, is procured by gently heating copper or mercury in diluted nitrous acid, and collecting the gas, which rises during the operation.

379. *Nitrous gas* suffocates animals which breathe it, and it is heavier than common air.

380. When in contact with oxygen gas, nitrous gas forms nitric acid, or aquafortis, which owes its yellow colour to the nitrous gas.

381. Most animal and vegetable substances are capable of becoming oxides.

Illustration The red part of the blood is an oxide. Sugar is a vegetable oxide. Oils, butter, and the flesh of animals, become rancid by the absorption of oxygen.

OF COMBUSTION.

382. Combustion, or burning, is that process by which combustible bodies absorb oxygen, and suffer the caloric it contains to escape as heat.

Illustration. Oxygen exists in the state of gas in the atmospheric air; when a combustible is heated to a certain degree, it possesses such an attraction for oxygen, that it absorbs it from the air, while the caloric which gave it the gaseous form, escapes or diffuses itself among the surrounding bodies, occasioning heat, or warmth.

383. Some bodies are combustible, others incumbustible.

Illustration. The term combustible is applied to every body capable of being burnt in atmospheric air, or in oxygen gas, and consequently of uniting with oxygen.

384. Those combustible substances which have resisted every attempt to decompose them, are called simple combustibles.

385. Hydrogen, sulphur, phosphorus, and carbon are simple combustibles. To these might be added all the metals; for they also are combustible and have not yet been decomposed. But from their possessing properties peculiar to themselves they have not generally been ranked among this class of bodies.

Ex. To prove that metals may actually be burnt, and give out light and heat, twist a small piece of iron wire into the form of a corkscrew, by rolling it round a small stick. Fix one end of it into a cork (previously made to fit a glass jar, filled with oxygen gas) and lap round the other end some cotton thread, dipped in melted wax

or tallow, set fire to the cotton thread, and immediately plunge the wire into the jar of oxygen gas. The wire will take fire from the cotton, and burn with great brilliancy, throwing out sparks in all directions During the combustion, the iron combines with the oxygen in the jar and an oxide of iron is formed, which will be found to be one-third heavier than the original piece of wire.

Observation. Dr. Thomson, in the last edition of his Chemistry, makes the following classification of simple combustibles.

"There are," he observes, "forty-three such substances known. I conceive they may be very conveniently classed under the following genera.

"I. Bodies forming acids by uniting with the supporters of combustion, or with hydrogen. The substances belonging to this genus are the eight following.*

1. Hydrogen
2. Carbon
3. Boron
4. Silicon
5. Phosphorus
6. Sulphur
7. Arsenic
8. Tellurium

All these bodies, except arsenic and tellurium, have been hitherto classed apart from the metals, under the name of *simple* combustibles.

"II. Bodies forming alkalies or bases capable of constituting neutral salts with acids, by uniting with the supporters of combustion.

"These bodies are 28 in number. They are all metals, and may be arranged under five families or groups.

1st Family.

1. Potassium
2. Sodium
3. Calcium
4. Barium
5. Strontium
6. Magnesium

2nd Family.

1. Yttrium
2. Glucinum
3. Aluminum
4. Yerconium

3d Family.

1. Iron
2. Nickle
3. Cobalt
4. Manganese
5. Cerium
6. Uranium

4th Family:

1. Zinc
2. Lead
3. Tin
4. Copper
5. Bismuth
6. Mercury
7. Silver

5th Family.

1. Gold
2. Platinium
3. Palladium
4. Rhodium
5. Iridium

* "I class along with them likewise osmium, from analogy."

"III. Bodies producing, by their union with the supporters of combustion, imperfect acids, or substances intermediate between acids and alkalies.

"These bodies are six in number, and belong all to the class of metals.

1. Antimony	3. Molybdenum	5. Columbium or Tantalum
2. Chromium	4. Tungsten	6. Titanium."

To this classification the following forcible objections have been made.

"Upon this arrangement it will be proper to observe, 1st. That whether hydrogen be acidifiable, depends on the truth of the theory which the author has adopted, viz. respecting the constitution of chlorine and muriatic acid gas. There is as yet no proof that hydrogen is acidifiable.

"2nd. It is impossible to force any oxide of silicon into the class of acids, according to the definition given of acids, in Vol. 2nd. of Thomson, viz: The word acid comprehends under it all substances possessed of the following properties: When applied to the tongue they excite that sensation which is called sour, or acid—They change the colour of vegetables to a red—They unite with water in almost any proportion—They combine with alkalies, earths, and most of the metallic oxides, and form salts.

"3rd It seems to me a strange perversion of language to class 18 of the metals, iron, gold, silver, copper, lead, tin, &c. &c. among the alkalies.

"4th. It is even yet extremely dubious whether the alkalies, with a metallic appearance (metalloids) ought to be ranked as metals: for, 1 They want the characteristic weight of metals. 2. They are extremely soluble in water. 3. Their oxides are heavier than the substance before it be oxided—Properties, until Sir Humphrey Davy forced these substances into company with metals, which metals were never allowed to possess. 4. Dr Clarke's experiments at Cambridge, on the metallization of the earths have obtained but little credit in London. Dr. *Brande's Journ.* 317.

"Again. His 3rd genus consists of bodies that are in-

termediate between acids and alkalies, a description hitherto usually applied to neutral salts; but no one who has procured the acids so called of chrome, molybdena, and tungsten, can doubt of the propriety of classing them among the acids, according to the usual meaning hitherto given by chemists to that word. To class silicon among the acidifiable bases, and to reject chrome, is indeed a classification that facts will not justify.

"The whole of this arrangement appears to me formed on considerations too theoretical; they may possibly be verified by future experiments, but they are not to be taken for granted in the present state of our knowledge, especially in an elementary system of the science of Chemistry." *Cooper.*

386. Compound combustibles are such bodies as are formed by the union of two or more of the simple combustibles.

Illustration. Common coal, bitumens, oils, and resin, being compounded of hydrogen, carbon, and others of the simple combustibles, are compound combustibles.

387. There are thirteen incombustible substances, nitrogen, the three alkalies, and the nine earths.

388. Certain substances are called supporters of combustion. They are such as must be present before combustible bodies will burn, and are either simple or compound.

389. Atmospheric air, nitrous oxide, nitric acid, &c. are compound supporters of combustion.

Illustration. If nitrous acid (aquafortis) be mixed with about half its weight of sulphuric acid, (oil of vitriol) and poured into oil of turpentine, the whole will imme-

diately burst into flame. In this experiment the oxygen of the nitrous acid, promotes the combustion.

390. Oxygen is a simple supporter of combustion, to which some chemists have added Chlorine and Iodine; and *Amper* has suspected a fourth, to which he has given the name of Fluorine.

Observation. In the last edition of this little work, page 86, I made some observations to show that the opinion of Sir Humphrey Davy with respect to Chlorine being a simple substance was highly improbable. I stated an experiment of Dr. Murray, in which he produced carbonic acid gas and water, from carbonic oxide, hydrogen and chlorine, which would not have been done unless the chlorine had furnished the oxygen to the carbonic oxide to form the carbonic acid, and to the hydrogen to form the water.

To this experiment Davy has objected, and contends, that when chlorine and hydrogen are exploded, no water is formed, whereas, if chlorine contained oxygen, a different result must have been the consequence. But from subsequent experiment, Murray insists, that the explosion induced between chlorine and hydrogen does produce water, by an union of the hydrogen to the oxygen of the chlorine And that this water combined chemically with the original muriatic acid gas remaining. And as Davy had denied that muriatic acid gas contained water in chemical union, Murray undertook to shew that it did, by the following experiment:—He formed muriate of ammonia, by combining muriatic acid gas with ammoniacal gas, both made dry by hot muriate of lime, which has a powerful affinity for moisture. He then distilled the muriate of ammonia, so as to obtain manifest signs of water. To these results J. Davy objected, by contending that the moisture produced was probably owing to an inaccuracy in the experiment, occasioned from the access of air. But Dr. Bostock and Dr. Trail of Liverpool, repeated the experiment of Mur-

ray, with every necessary precaution to exclude the atmospheric air, and found the muriate of ammonia as above formed, did afford water. *And in the latter end of* 1817, Dr. Ure, professor of chemistry at Glasgow, by passing the vapour of the muriate of ammonia through laminæ of pure silver and copper ignited in glass tubes, found that water and hydrogen were copiously evolved, and that the metals were converted into metallic muriates.—Dr. Murray, by a series of experiments made with the greatest precaution, confirmed those of Dr. Ure, in which he indisputably procured water from the dry muriate of ammonia—This water it is evident could not have proceeded from the ammoniacal gas, as that substance is composed only of hydrogen and nitrogen; it must therefore have proceeded from the muriatic acid gas with which it was chemically combined.

Professor Cooper in his notes to Thomson's Chemistry, makes the following just remarks on the above, which he has *there* more minutely detailed. "I consider these experiments fatal to the whole theory of Sir H. Davy, adopted by Dr. Thomson, for they enable us to account for the water formed by the hydrogen exploded with the oxygen of the chlorine." He adds, "To me they seem also fatal to the theory that constitutes iodine and fluorine supporters of combustion; for iodine is always procured by means of some substance that gives out its oxygen in the process. And fluorine is so indecisively ranked in this class as to form but a slight difficulty. *Oxygen alone then seems likely to be reinstated as the exclusive supporter of combustion.*"

Mode of procuring Iodine.—Iodine may be obtained by the following process:

Pulverize kelp, and dissolve it in water; filter the solution, and evaporate it till all the chrystals of common salt that can be obtained have separated from it. Mix the mother liquor with sulphuric acid, which boil for some time. (By this means a great quantity of muriatic acid, and of sulphuretted hydrogen, which impede the collection of the iodine, are previously removed.) Then put the liquid into a small retort, and mix with it

as much black oxide of manganese as the quantity of sulphuric acid that has been previously added. Apply heat. A violet coloured vapour arises, which is to be driven into a proper receiver, against which it condenses into a black brilliant matter. This substance is iodine. The smell is disagreeable and very similar to that of chlorine, tho' not so strong; and, like chlorine, possesses the property of destroying vegetable colours. When converted into vapour it has a very intense and beautiful violet colour. It was from this colour Gay Susac termed it *iode*, from which it was changed by Sir Humphrey Davy into *iodine*, as better suited to our language.—Iodine has the property of combining with starch, and forming with it a compound of a fine blue colour. For this purpose, triturate starch with an excess of iodine, dissolve the mixture in potash, and add a vegetable acid. The compound falls down in the state of fine blue powder. Starch is a delicate test of iodine.

FLUORINE. M. Amper having adopted the views of Sir Humphrey Davy respecting chlorine, was led to compare the fluoric acid and muriatic acids, and to draw similar conclusions with respect to the composition of both. According to Davy's theory, the base of muriatic acid was hydrogen combined with chlorine, a supporter of combustion. Therefore, admitting the composition of both to be similar, he supposed fluoric acid must likewise be a compound of hydrogen and an unknown supporter of combustion, to which unknown supporter, he has since given the name of *fluorine*. But he was unable to obtain it in a separate state.

The evidence of Davy with respect to the existence of fluorine is as follows.—When fluoric acid and potassium are brought into contact, a violent action takes place; a solid white substance is formed, and a quantity of hydrogen gas is discharged. Supposing the fluoric acid free from water, he concluded the fluorine and the potassium combined and formed a solid substance, while the hydrogen previously united to the fluorine makes its escape in the form of gas. To prove that fluoric acid of *a certain* specific gravity was free from water, he formed

with it a fluate of ammonia, by placing it in contact with ammoniacal gas, till it became saturated with the alkali. He then heated it, and did not discover that it gave out any water But, "as the *fluoric acid* and fluor spar employed *to form* the acid, both contain water, it is highly probable that the gas does." Messrs. Davy, in operating on the salts formed by muriatic and ammoniacal gas, could not procure water; while Mr. Murray, Dr. Bostock, Dr Trail, and Dr. Ure did. "For the same reason that chlorine seems to combine with oxygen during the process of procuring it, so may iodine and fluorine; and we are likely to be brought back to the elegant simplicity of the Lavoserian doctrine, that the only supporter of combustion is oxygen" *Cooper.*

391. The heat produced by combustion, is derived from the oxygen gas of the atmosphere.

Illustration. When we kindle a fire with wood or coals in order to procure heat, a continual stream of atmospheric air flows towards the fire place, to occupy the vacancy left by the air that has been decomposed or robbed of its oxygen. Every fresh portion of air, as it arrives at the fire place, is in its turn decomposed also. Hence a continual supply of caloric or heat is furnished without intermission, until the whole of the combustible is saturated with oxygen. As the wood or coal burns, light as well as heat is disengaged. The carbon of the wood or coal unites to the oxygen of the acid and forms carbonic acid gas, while another portion of the oxygen unites to the hydrogen and forms water. When the combustion is over, the earthy parts only of the combustible remains.

392. No combustible body can burn without atmospheric air, or rather without oxygen, which is a component part of the atmospheric air.

Illustration. Place a lighted candle under a glass jar,

inverted over a plate full of water; the candle will be gradually extinguished, as it exhausts the oxygen contained in the air of the jar.

393. The greater the quantity of oxygen gas which any body is capable of absorbing or decomposing, the greater will be the heat produced.

394. When a body is changed into an *oxide* by combustion, it is said to be *oxidized;* but when changed into an *acid*, the term *oxygenized* is used.

395. No part of a substance is destroyed or annihilated by combustion; the component parts are merely separated from each other to form new and various combinations.

OF WATER.

396. Water is a compound of fifteen parts by weight of hydrogen, and eighty-five of oxygen, in every one hundred parts.

397. Water is decomposed or separated into its constituent parts, by several operations of nature.

Illustration. All living vegetables have the power of decomposing water, by a secret operation peculiar to themselves. They combine a part of the hydrogen and oxygen of the water with the carbon of the atmosphere and of the soil, to form vegetable oils, wax, gum, resin, sugar, &c. while the superfluous oxygen is given off by the leaves.

398. Water may also be decomposed, and

again formed by artificial and chemical means.

Illustration. If an empty jar be held over the flame emitted from hydrogen gas, when burning, (as described under the article hydrogen) the hydrogen emitted will combine with the oxygen of the atmospheric air, and water will be formed, which will be deposited in drops within the sides of the jar.

399. Hydrogen is constantly emanating from every animal and vegetable substance, in a state of decay or putrefaction. It is emitted from various mines and volcanoes.

400. Water takes a solid form in the state of ice, and when combined with lime, marble and other substances.

401. Spring water, although the clearest and most inviting to look at, is frequently more unfit for common use than any other. It becomes pure or polluted in proportion as the earth through which it passes is less or more impregnated with saline or metallic substances.

That water in general ought to be preferred which sits lightest on the stomach; is fresh, lively and agreeable to the taste; that which boils pease and pulse quickest, and mixes readily with soap without curdling.

OF MINERAL WATERS.

402. When water contains such an excess of any foreign substance, that it cannot be used for domestic purposes, it is called *mineral water.*

403. The acids, the alkalies, and the salts, are the three classes of substances, which unite with water in forming mineral waters.

404. Carbonic acid is most frequently combined with water, to which it gives a briskness, resembling that of a fermenting liquor.

405. Sulphurous acid is found combined with waters in the vicinity of volcanoes, and in all hot springs, which are then called sulphurous waters.

406. The only alkali which has been observed in mineral waters uncombined is soda, and the only earthy bodies are silex and lime.

407. The neutral salts are most frequently to be met with in mineral waters.

408. Sulphate of lime, of soda, and of magnesia, (or sulphuric acid, united with these substances) are neutral salts found in mineral waters.

409. Sulphate of magnesia is the medicine, known by the name of Epsom salts, and is found in great abundance in the mineral springs near Epsom.

410. The muriates are more common in water, than any other of the salts.

OF VEGETABLE SUBSTANCES.

411. The principal substances which enter into the composition of vegetables are carbon, hydrogen and oxygen.

412. Sugar is the most frequent ingredient met with in vegetables.

Illustration. It is contained in most abundance in the sugar-cane and sugar maple. Beet-root, carrots, turnips, and most kinds of grain, also contain sugar in abundance.

413. Gum, or mucilage, is also found in abundance in vegetables.

414. Gum arabic, and cherry-tree gum, are most used in chemistry. They are oozed out from trees, by the heat of the sun.

415. Jelly is also an ingredient in vegetables. It is generally procured from the juices of blackberries and other fruits.

416. Tan, or tannin, is very abundant in the bark of most vegetables, particularly the oak.

417. It is remarkable for astringency, and it has a bitter taste.

Illustration. The most important property in tan is in forming the substance called leather. When applied to the skin of an animal, (which is called gelatine, or glue, in chemistry) a new, and insoluble compound, or leather, is formed.

418. The *bitter principle* is another constituent part of vegetables. It is most conspicuous in hops, quassia, &c.

419. Opium, or the narcotic principle, is also contained in many plants.

Illustration. This substance abounds in white poppies, and in plants which exhibit a milky juice, when their stalks are broken, such as garden lettuce, dandelion, &c. This milky juice, when exposed to the sun, becomes of a dark colour, and concretes into opium.

420. *Gluten* and *Starch* form the essential

parts of the flour, made from wheat, barley, potatoes, &c.

Ex. To obtain gluten and starch, moisten any quantity of wheat flour with water, and knead it into a tough paste. Let a small stream of water keep dropping upon this paste while it is constantly worked up with the hands. The water will at first run off white and turbid, owing to the starch which it contains; but when it runs off quite clear, nothing is left in the hands but a tough stringy substance, which, when dried, resembles glue or horn, and is pure gluten Starch is made by heating the mixture which has run off from the gluten, until the water is evaporated, and dry starch remains.

421. Wax is collected by bees from the leaves of the trees and plants. It is not altered in its nature by these animals.

422. Resin, like gum, exudes from most trees, particularly from firs.

423. The substances known by the names of balsams, varnishes, turpentine, rosin, tar, and pitch, are all resins. They are obtained from trees, by operations peculiar to the manufacture of each.

424. *Caoutchouc*, or Indian rubber, is a milky gum, which exudes from certain trees in South America: upon being exposed to the air, it hardens into the consistence in which we see it in this country.

425. Cork is the bark of a species of the oak. It is called in chemistry *suber*.

426. Camphor is a white concrete substance, found in several vegetables, but is most abundant in a particular tree in the East Indies.

427. It is highly inflammable, and will even burn on the surface of water, on which it floats.

428. Camphor has a pungent smell, and sharp taste. It is used in medicine.

429. Vegetables contain oils in great abundance. These exist in two states, called fixed oil, and volatile or essential oil.

430. Vegetable fixed oil is obtained by squeezing or pressing the seeds and kernels of most vegetables, or by keeping them for some time in hot water, when their oil rises to the surface.

Illustration: Olive oil, oil of almonds, linseed oil, &c. are obtained by bruising these several productions, in machinery made for the purpose.

431. Essential, or volatile oil, is what is commonly called an essence.

Illustration. Essences are generally obtained by distilling plants, the peculiar smell of which they retain, as oil of peppermint, oil of lavender, oil of turpentine, &c. These are also called spirits of lavender, &c.

432. Volatile oil is distinguished from fixed oil, by its leaving no greasy spot or stain on linen or paper, when dropped upon it.

433. The essential oils affect the tongue with a sensation of heat and bitterness, and they are highly inflammable.

Illustration. Squeeze the skin of an orange or lemon near the flame of a candle; the essential oil will fly out and burn with a bright white flame. By simply rubbing a lump of sugar against the skin of an orange, the sugar will imbibe this essential oil.

OF ANIMAL SUBSTANCES.

434. The simple bodies, of which animal substances are compounded, are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, and lime.

435. *Gelatine*, or glue, is the most common compound ingredient found in animal substances.

436. It is the principal part of the skin and flesh of animals. Blood and milk always contain it, and it is also found in bones, horns, and hair.

Illustration. The process of making jelly from calves' feet, and the substance called isinglass, by boiling the skins of fishes, are familiar instances of the production of gelatine When the soup or jelly made by boiling beef, &c. becomes hard and dry, from the water being evaporated from it, it is called portable soup, and is a real glue. The common glue, used by workmen, is made by boiling down the parings of skins, and the refuse of the tanners and leather dressers.

437. *Albumen* is the name given by chemists to the white of an egg, in which it is combined with sulphur and soda.

Illustration. Silver spoons, used in eating eggs, are blackened from the sulphur contained in the albumen adhering to the silver.

438. Albumen constitutes the serum or jelly-like substance of the blood. When dried, it becomes a brittle semi-transparent substance, like horn.

439. Sugar is found in the milk of animals, and is in all respects similar to the sugar obtained from vegetables.

440. The oils found in animals, consist of fat or tallow, spermaceti, train, or fish oil, and butter.

441. Spermaceti differs from the other animal oils, in being found in a concrete or crystallized state, in the brain of the Spermaceti whale.

442. The oils obtained from fishes are fluid at the temperature of the atmosphere, while the oils of land animals concrete into the substance called fat or tallow.

443. Phosphorus abounds in animal substances.

Illustration. Phosphorus exhales copiously from putrid fish, in the state of phosphuretted hydrogen gas, spontaneously emitting light in the dark.

444. The bones of animals are composed of phosphate of lime, carbonate of lime, and gelatine.

445. The clot, or thick part formed in blood, when taken from an animal body, is albumen, gelatine, and oxide of iron, which gives it the red colour.

446. The serum, or watery part, is composed of albumen, and gelatine, mixed with muriate and carbonate of soda, and phosphate of lime.

447. The curd, formed in the milk of ani-

mals, is albumen, and the whey consists of serum and sugar.

448. Milk also contains an animal oil in great abundance, which is separated from it by agitation, and concretes into butter.

OF FERMENTATION.

449. Fermentation is a change which takes place in vegetable matters, containing sugar and mucilage, mixed with luke-warm water.

Illustration 1. The fermentation of this description of vegetables is called the *vinous* fermentation, because in this way, wines, as well as beer and cider, are prepared.

2 In the vinous fermentation, an intestine motion or agitation takes place in the fluid, it becomes thick and muddy, and the heat increases. Carbonic acid gas is sent off from the liquor, and the fermentation ceases, by the thick part falling to the bottom. The liquor has then lost its sweet taste, and it is found to contain a quantity of spirits or alcohol, which may be separated from it by distillation.

450. The *acetous* fermentation takes place when any vinous or spirituous fluid, such as wine or beer, is exposed to the air, from which it absorbs oxygen, and becomes vinegar.

451. Putrefaction is also a process of fermentation, peculiar both to animal and vegetable substances.

Illustration. Ammonia, which is composed of nitrogen and hydrogen, is always the result of putrefaction. In putrefaction therefore there is a total decomposition, or dissolution of the parts of the animal or vegetable substance, and entire new products are formed.

EXPERIMENTS

ILLUSTRATING THE GENERAL PRINCIPLES OF

CHEMISTRY.

No. 1. TAKE a small phial about half full of cold water; grasp it gently in the left hand, and from another phial pour a little sulphuric acid or oil of vitriol, drop by drop, into the water. A strong sensation of heat will immediately be perceived. This, by the addition of more acid, may be increased to many degrees beyond that of boiling water.

2. Take a small phial in one hand, containing some sal ammoniac (pulverized muriate of ammonia;) pour a little water upon it, and shake the mixture. In this instance a sensation of cold will immediately be felt.

3. Into a tea-cup placed upon a hearth, and containing about a table spoonful of oil of turpentine, pour about half the quantity of strong nitrous acid (aquafortis) previously mixed with a few drops of sulphuric acid. The moment the acids come in contact with the turpentine, flame will be produced. In this experiment the acids must be mixed in a phial, tied to the end of a stick, and at arm's length pour its contents into the oil; (as the sudden combustion sometimes occasions a part of the liquids to be thrown out of the vessel.)

4. Put an ounce or two of the black oxide of manganese into a small glass retort, pour a little sulphuric acid upon it, and apply heat. Oxygen gas will be disengaged.

5. Into a small glass retort put a mixture of two parts of quick-lime and one of sal ammoniac (muriate of ammonia) both in powder. Apply heat, and ammoniacal gas will come over.

6. Convey some muriatic gas into a glass jar containing a portion of the gas produced in experiment 5. From the mixture of these two invisible gases a solid substance will be produced, viz. the common sal ammoniac; this may be perceived to deposit itself upon the side of the vessel in a neat chrystallized form.

7. Convey some carbonic acid gas into a glass jar containing a portion of ammoniacal gas. The instant the two gases come in contact a great absorption will take place, and solid carbonate of ammonia will be formed on the inner surface of the jar.

8. Put half an ounce of quicksilver into a wine glass, and pour about an ounce of diluted nitrous acid upon it. The nitrous acid will be decomposed by the metal with astonishing rapidity; the bulk of the acid will be quickly changed to a beautiful green, while its surface exhibits a dark crimson, and an effervescence indescribably vivid and pleasing, will go on during the whole time the acid acts upon the quicksilver. When a part only of the metal is dissolved, a change of colour will again take place, and the acid by degrees will become paler, till it is as pellucid as pure water. This is one instance of a metallic solution by means of an acid, in which the opacity of a metallic body is completely overcome, and the whole rendered perfectly transparent.

9. Take the metallic solution formed in the last experiment, add a little more quicksilver to saturate the acid; then place it at some distance over the flame of a lamp, so as gently to evaporate a part of the water. The new formed salt will soon be seen to shoot into needle-like prismatic chrystals, crossing each other in every possible direction, affording an instance of a metallic salt.

10. Pour a drachm by weight of strong nitrous acid into a wine-glass, add two drachms of distilled water,* and, when mixed, throw a few very small pieces of granulated tin into it. A violent effervescence will take place, the lighter particles of the tin will be thrown to the top of the acid, and be seen to play up and down in the liquor for a considerable time, till the whole is dissolved. This is another example of a transparent liquid holding a metal in solution.

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* Where distilled water is not at hand, clean rain or river water will answer nearly as well for most purposes.

11. Take an ounce of a solution of potash, pour upon it half an ounce of sulphuric acid; lay the mixture aside, and when cold, chrystals of sulphate of potash will be formed in the liquor. Here a mild salt has been formed from a mixture of two *corrosive* substances.

12. Take caustic soda one ounce, pour over it one ounce of muriatic acid, both of these corrosive substances. The product will be our common table salt.

13. Fluids acted upon by chemical attraction sometimes become solid, as when carbonate of ammonia and alcohol are mixed together in equal quantities, and the mixture thrown on blotting paper.

14. Mix in a wine-glass equal quantities of a saturated solution of muriate of lime, and a saturated solution of carbonate of potash, both transparent *fluids*; stir the mixture, and a solid mass will be the product.

15. Take the substance produced in the foregoing experiment, and pour a very little nitric acid upon it. The consequence will be, the solid matter will be again taken up, and the whole exhibit the appearance of one homogenous fluid. An instance of a solid *opake* mass being converted by a chemical agent to a transparent liquid.

16. A solid precipitate is produced when a solution of common salt, and the nitrate of silver, also in solution, are presented to each other.

17. Again a liquid aggregate may be produced, by adding and briskly triturating together equal parts of sulphate of magnesia, and muriate of ammonia.

18. Put thirty grains of phosphorus into a Florence flask, with three or four ounces of water. Place the vessel over a lamp, and give it a boiling heat. Balls of fire will soon be seen to issue through the water, after the manner of an artificial firework, attended with the most beautiful corruscations.

19. Prepare a mixture of equal parts of lump sugar and oxygenated muriate of potash; put a small quantity of this mixture upon a plate or a tile; then dip a fine glass rod or tobacco pipe into a phial of sulphuric acid, so as to convey the smallest quantity of the acid;

with this touch the powder, and an immediate burst of flame will be the consequence.

20. Pour boiling water upon a little red cabbage sliced, and when cold decant the clear infusion. Divide the infusion into three wine glasses. To one add a solution of allum, to the second a solution of potash, and to the third a few drops of muriatic acid. The liquor in the first glass will assume a purple, the second a bright green, and the third a beautiful crimson. Here is an instance of three different colours from the same vegetable infusion, merely by the addition of three *colourless* fluids.

21. Into a wine glass of water put a few drops of prussiate of potash, and a little dilute solution of sulphate of iron into another glass: by pouring these two *colourless* fluids together, a beautiful deep blue colour will be immediately produced, which is the true Prussian blue.

22. Spread a piece of tinfoil, such as is used for coating electrical jars, upon a piece of thick paper; pour a small quantity of solution of nitrate of copper upon it. Fold it up quickly, and wrap it round carefully with the paper, more effectually to exclude the atmospheric air. Place it then upon a tile, and in a short time *combustion* will commence, and the tin will inflame.

23. Take three parts of nitre, two of potash, and one of sulphur; all of these should be thoroughly dry; then mix them by rubbing them together in a warm mortar. The resulting compound is called *fulminating powder*. If a little of this powder be placed upon a fire-shovel, over a hot fire, it gradually blackens, and at last melts. At that instant it explodes with a violent report.

24. To a glass of water suspected to contain carbonic acid, add a small quantity of any of the other acids. If carbonic acid be present, it will become visible by a sparkling appearance on the sides of the glass, and surface of the fluid.

25. Prepare two glasses of rain water, and into one of them drop a single drop of sulphuric acid. Pour a little *nitrate of silver* into the other glass, and no

change will be perceptible. Pour some of the same solution into the first glass, and a white precipitate of sulphate of silver will appear.

26. Prepare two glasses as in the last experiment, and into one of them put a drop or two of *muriatic acid.* Proceed as before, and a precipitate of muriate of silver will be produced.

27. Mix one ounce of litharge of lead with one drachm of pulverized muriate of ammonia, and submit the mixture to a red heat in a clean tobacco-pipe. The increase of temperature will separate the ammonia in the form of gas, and the muriatic acid will combine with the lead. When the compound is well melted, pour it into a metallic cup, and you will have a true muriate of lead, of a bright yellow colour, the brilliancy of which may be much heightened by grinding it as usual with oil. In this state it forms the colour called patent yellow.

28. Take one ounce of red lead, and half a drachm of charcoal in powder, incorporate them well in a mortar, and then fill the bowl of a tobacco-pipe with the mixture. Submit it to an intense heat in a common fire, and, when melted, pour it out upon a slab. The result will be metallic lead completely revived.

29. Take a little *red lead,* expose it to an intense heat in a crucible, and pour it out when melted. The result will be metallic glass, and will furnish an example of the vitrification of metals.

30. If a few strips of dyed linen cloth, of different colours, be dipped into a phial of oxigenated muriatic acid, the colours will be quickly discharged; for there are few colours that can resist the energetic effect of this acid. This experiment may be considered as a complete example of the process of bleaching coloured goods.

31. Having found a piece of blue linen cloth, that will bleach in oxigenated muriatic acid, dip the tip of the finger in a solution of *muriate of tin,* and press it while wet with the solution upon a strip of this cloth. After an interval of a few minutes, immerse the cloth in the phial of liquid oxygenized muriatic acid, and when it

has remained in it the usual time, it will be found that the spot which was wet with the muriate of tin, has preserved its original colour, while the rest of the cloth has become white.

32. Dip a piece of white calico in a strong solution of acetate of iron; dry it by the fire, and lay it aside for three or four days. After this, wash it well in hot water, and then dye it black, by boiling it for ten minutes in a strong decoction of Brazil wood. If the cloth be now dried, any figures printed upon it with a *colourless* solution of muriate of tin, will appear of a beautiful scarlet, although the ground will remain a permanent black.

33. Dissolve four drachms of sulphate of iron in one pint of cold water, then add about six drachms of lime in powder, and two drachms of finely pulverized indigo, stirring the mixture occasionally for 12 or 14 hours. If a piece of white calico be immersed in this solution for a few minutes, it will be dyed green: and by exposure to the atmosphere only for a few seconds, this will be converted to a permanent blue.

34. If a piece of calico be immersed in a solution of sulphate of iron, and, when dry, washed in a weak solution of sulphate of potash, a permanent colour will be produced, viz. the buff of the calico printers.

35. Boil equal parts of arnotto and common potash with water, till the whole are dissolved. This will produce the pale reddish buff, so much in use, and sold under the name of nankeen dye.

36. If muriate of tin, newly made, be added to a solution of indigo in sulphuric acid, the oxygen of the indigo will be absorbed, and the solution instantly converted to a *green*. It is on the same principle that muriate of tin is employed in cleansing discoloured leather furniture; as it absorbs the oxygen, and the leather is restored to its natural colour.

37. Take a piece of very dark olive-coloured linen that has been dyed with fustic, quercitron bark, or weld, and spot it in several places with a *colourless* solution of muriate of tin. Wherever the cloth has been touched with this solution, the original colour will be dis-

charged, and spots of a bright yellow will appear in its stead.

38. Dip a piece of white calico in a cold solution of sulphate of iron, and suffer it to become entirely dry. Then imprint any figures upon it with a strong solution of colourless citric acid, and allow this also to dry. If the piece be then well washed in pure warm water, and afterwards boiled in a decoction of logwood, the ground will be dyed either of a slate or black colour, according to the metallic solution, while the printed figures will remain beautifully white. This experiment is designed to show the effect of acids in discharging vegetable colour.

39. If lemon juice be dropped upon any kind of buff colour, the dye will be instantly discharged. The application of this acid, by means of the block, is another method by which calico-printers give the white spots or figures to piece goods. The chrystallized acid, in a state of solution, is generally used for this purpose. These few experiments will give the student some idea of the nature of calico-printing.

40. Take a slip of blue litmus paper, dip it into acetous acid, and it will immediately become red. This is a test so delicate, that according to Bergman it will detect the presence of sulphuric acid, even if the water contain only one part of acid, to thirty-five thousand parts of water. Litmus paper, which has been thus changed by immersion in acids, is, when dried, a good test for the alkalies; for, if it be dipped into a fluid containing the smallest portion of alkali, the dried will disappear, and the paper be restored to its original blue colour.

41. Take a slip of turmeric paper, and dip it into any alkaline solution; this will change the yellow to a deep brown. In many cases turmeric is preferable to litmus paper for detecting alkali in solution, as it suffers no change from carbonate of lime, which is often found in mineral waters. This paper will detect the presence of soda, though it should amount to no more than $\frac{1}{2200}$th part of the water. The paper thus changed by

an alkali, would, if dried, be still useful as a test for acids, as these restore its original yellow.

42. Write upon paper, with a diluted solution of muriate of copper; when dry, it will not be visible, but on being warmed before the fire, the writing will become of a beautiful yellow.

43. Write with a solution of muriate of cobalt, and the writing, while dry, will not be perceptible; but if held towards the fire, it will then gradually become visible; and if the muriate of cobalt be made in the usual way, the letters will appear of an elegant green colour.

44. Draw a landscape with Indian ink, and paint the foliage of the vegetables with muriate of cobalt, the same as that used in experiment No. 43, and some of the flowers with acetate of cobalt, and others with muriate of copper. While this picture is cold, it will appear to be an outline of a landscape, or winter scene; but when gently warmed, the trees and flowers will be displayed in their natural colours, which they will preserve only while they continue warm. This may be often repeated.

45. Write with blue nitrate of silver, which when dry will be entirely invisible; hold the paper over a vessel containing sulphate of ammonia, and the writing will appear very distinct. The letters will shine with the metallic brilliancy of silver.

46. Write with a weak solution of sulphate of iron; let it dry, and it will be invisible. By dipping a feather in tincture of galls, and drawing the wet feather over the letters, the writing will be restored, and appear black.

47. Write with a similar solution, and when dry wash the letters in the same with prussiate of potash, and they will be restored of a beautiful blue.

48. Fill a glass jar with oxymuriatic acid gas. If nickel, arsenic, or bismuth in powder, be thrown into this gas, and the temperature of the atmostphere be not lower than 70°, the metal will inflame, and continue to burn with the most brilliant combustion.

49. Into a large glass jar, inverted upon a flat brick tile, and containing near its top a branch of fresh rose-

mary, or any other such shrub, moistened with water, introduce a flat thick piece of heated iron, on which place some gum benzoin in gross powder. The benzoic acid, in consequence of the heat, will be separated, and ascend in white fumes, which will at length condense, and form a most beautiful appearance upon the leaves of the vegetable. This will serve as an example of sublimation.

50. Fill a glass tumbler half full of lime water; then breathe into it frequently with the mouth open; at the same time stirring it with a piece of glass. The fluid, which before was perfectly transparent, will presently become quite white, and, if suffered to remain at rest, real chalk will be deposited.

51. Mix a little acetate of lead with an equal portion of alum; both in fine powder: stir them together with a bit of glass or wood, and no chemical change will be perceptible; but if they be rubbed together in a mortar, the two solids will operate on each other; an intimate union will take place, and a fluid will be produced.

52. Put a little common magnesia in a tea-cup upon the hearth, and suddenly pour over it as much concentrated sulphuric acid as will cover the magnesia. In an instant the mixture will take fire.

53. If a few pounds of a mixture of iron filings and sulphur be made into a paste with water, and buried in the ground for a few hours, the water will be decomposed with so much rapidity, that combustion and flame will be the consequence, and an artificial volcano will be produced.

54. Put a little spirits of wine in a tea-cup, set it on fire, and invert a large glass over it. In a short time an aqueous vapour will be seen to condense upon the inside of the glass, which, by means of a dry sponge, may be collected, and its quantity ascertained. This may be adduced as an example of the formation of water by combustion.

55. Pour a little water into a phial containing about an ounce of olive oil. Shake the phial, and if the contents be observed, we shall find that no union has taken

place. But if some solution of caustic potash be added, and the phial be then shaken, an intimate combination of the materials will be formed by the disposing affinity of the alkali, and a perfect soap produced.

56. Drop upon a clean plate of copper, a small quantity of solution of nitrate of silver; in a short time a metallic vegetation will be perceptible, branching out in very elegant and pleasing forms, furnishing an example of metallic revivification.

57. Dissolve an ounce of acetate of lead in about a quart or more of water, and filter the solution. If this be put into a glass decanter, and a piece of zinc suspended in it by means of a brass wire, a decomposition of the salt will immediately commence, the lead will be set at liberty, and will attach itself to the remaining zinc, forming a metallic tree.

58. For want of a proper glass vessel, a table-spoon full of ether may be put into a moistened bladder, and the neck of the bladder closely tied. If hot water be then poured upon it, or if it be held to the fire, the ether will expand, and the bladder become inflated.

59. Place a lighted wax taper within a narrow glass jar, then take a jar or phial of carbonic acid gas, and cautiously pour it into the jar containing the taper. This being an *invisible* gas, the operator will appear to invert merely an *empty* vessel, though the taper will be as effectually and instantaneously extinguished, as if water itself had been used.

60. Make a little charcoal perfectly dry, pulverize it very fine, and put it in a warm tea-cup. If some strong nitrous acid be now poured upon it, a combustion and inflammation will immediately ensue.

61. Put a bit of phosphorus into a small phial, then fill one-third with boiling olive-oil, and cork it close. Whenever the stopper is taken out in the night, light will be evolved, sufficient to show the hour upon a watch.

62. Take a glass tube with a bulb, in form of a common thermometer; fill it with cold water, and suspend it by a string. If the bulb be frequently and continally moistened with pure sulphuric ether, the water will presently be frozen, even in summer.

63. Dissolve five drachms of muriate of ammonia, and five drachms of nitre, both finely powdered, in two ounces of water. A thermometer immersed in the solution, will show that the temperature is reduced below 32°. If a thermometer tube, filled with water, be now suspended within it, the water will soon be as effectually frozen, as in the last experiment.

64. A diluted solution of pure potash will speedily remove greasy spots. Spots from wax candles, or white paint may be removed by spirits of turpentine.

65. Dissolve common hard soap in alcohol, drop the solution into distilled water, and no change will be perceptible. If the water be what is called hard water, a milkiness will instantly be produced, more or less opaque as the water is more or less pure. This effect is owing to the alkali in the soap quitting the oil when water contains any substance, for which it has a stronger affinity than for oil. All acids and all earthy and metallic salts decompose soap. Their presence occasions the property called hardness in water.

66. Cooking utensils, when made of certain metals, sometimes communicate a poisonous quality to the victuals put into them. If copper be suspected to exist in any liquid, as in the vinegar in which pickles are kept, for instance, it may be immediately detected by pouring into the acid a solution of pure ammonia. In this case a beautiful azure colour will be formed, and it will be dangerous to make any use of the vinegar or pickles.

67. Water kept in leaden vessels, or which passes through leaden pipes is frequently injurious to health. By adding to the suspected water about half its bulk of water impregnated with sulphuretted hydrogen gas, a dark brown or blackish colour will be given to the liquid, if lead be present; a precipitate will afterwards be found; upon applying the heat of a blow-pipe to it globules of metallic lead are yielded.

68. Flake white, or ceruse, is frequently added to wines and spirits, by unprincipled dealers, in order to correct the acidity of fermentation. Many fatal accidents have happened to the lower classes from the use

of such beverages. The following test will discover the presence of this dangerous article. Put into a small phial, sixteen grains of dry sulphuret of lime, and twenty grains of acidulous tartrite of potash (cream of tartar.) The phial is to be filled up with water, and shaken for eight or ten minutes after being well corked. When some of this test, after being decanted clear from the powder, is poured into the suspected liquor, a dark coloured precipitate will be formed, if lead be present.

69. Melt sulphur in a small iron ladle, and carry it into a dark room, in the state of fusion. If an ounce or two of copper filings be now thrown in, light will be evolved.

70. Take a phial with solution of sulphate of zinc, and another containing a little liquid ammonia, both transparent fluids. By mixing them, a curious phænomenon may be perceived—the zinc will be immediately precipitated in a white mass, and, if then shaken, almost as instantly re-dissolved.

71. Add a few grains of oxygenized muriate of potash to a tea-spoon full or two of alcohol, drop one or two drops of sulphuric acid upon the mixture, and the whole will burst into flame, forming a very beautiful appearance.

72. If 20 grains of phosphorus, cut very small, and mixed with 40 grains of finely powdered zinc, be put into 4 drachms of water, and 2 drachms of concentrated sulphuric acid be added thereto, bubbles of inflamed phosphuretted hydrogen gas will quickly cover the whole surface of the fluid in succession, forming a real fountain of fire.

73. If flowers, or any other figures, be drawn upon a riband or silk with a solution of nitrate of silver, and the silk moistened with water, be then exposed to the action of hydrogen gas, the silver will be revived, and figures, firmly fixed upon the silk, will become visible, and shine with metallic brilliancy.

74. By proceeding in the same manner, and using a solution of gold in nitro-muriatic acid, silks may be permanently gilt at a most insignificant expense, and will exhibit an appearance the most beautiful that can be conceived.

75. If a small thermometer be placed in a glass vessel containing about an ounce of a solution of soda, on adding a sufficient quantity of muriatic acid to saturate the soda, the mercury in the thermometer will expand, affording an instance of heat being produced by the formation of a salt.

76 Let the last experiment be repeated, with the *carbonate* of soda, instead of pure soda; the mercury will now sink in the thermometer. Here, though the same kind of salt is formed, cold is produced.

77. Fill a thermometer tube with tepid water, and immerse in a glass vessel of water of the same temperature, containing a mercurial thermometer. If the whole be now placed in a bed of snow, or in a freezing mixture, the water in the tube will suffer a progressive diminution of volume, until it arrives at about 40°; it will then begin to expand gradually, until it becomes solid. This shows how ice is able to swim on the surface of the water.

78. It is an interesting experiment to place a glow-worm within a jar of oxygen gas, in a dark room. The insect will shine with much greater brilliancy than it does in atmospheric air, and appear more alert. As the luminous appearance depends on the will of the animal, this experiment affords an instance of the stimulus which this gas communicates to the animal system.

79. If a morsel of dry nitrate of silver, (lunar caustic) be laid on a piece of burning charcoal, the metallic salt will immediately deflagrate, throw out the most beautiful scintillations that can be imagined, and the surface of the charcoal will be richly coated with metallic silver.

80. Drop a piece of phosphorus about the size of a pea into a tumbler of hot water, and from a bladder, furnished with a stop-cock, force a stream of oxygen directly upon it. This will afford the most brilliant combustion under water that can be imagined.

81. Drop a little leaf-gold into nitro-muriatic acid, and it will instantly disappear. This experiment is designed to show the great solubility of the metals, when submitted to a proper menstruum.

82. Pour a little purified nitric acid into one wine-glass, and muriatic acid into another, and drop a little

leaf-gold into each. Here neither of these corrosive acids will act at all upon the metal, the gold will remain untouched. Now pour the whole contents of the two glasses together, and the metal will disappear, and be as effectually dissolved as in the last experiment.

83. Put into a wine-glass about a scruple of oxidized manganese and potash, and an equal quantity of the same compound into another glass. On one pour hot, and on the other cold water. The hot solution will exhibit a beautiful green colour, the cold one, a deep purple.

84. If a small portion of the same compound be put into several glasses, and water at different temperatures be poured upon each, the contents of each glass will exhibit a different shade of colour. This experiment affords another instance of metals producing various colours according to their different states of oxidizement.

85. Into a glass of water containing a small portion of common salt, drop some of a clear solution of nitrate of silver, and an insoluble precipitate of muriate of silver will be produced. This experiment gives some idea of the method of analysing mineral waters. Every 100 grains of this precipitate, when dried, indicate 42 grains of common salt.

86. Into distilled water, drop a little spiritous solution of soap, and no chemical effect will be perceived; but if some of the same solution be added to hard water, a milkiness will immediately be produced more or less, according to the degree of its impurity. This is a good method of ascertaining the purity of spring water.

87. If a little pure white calomel be rubbed in a glass mortar with a little colourless solution of caustic ammonia, the whole will become intensely black.

88. Dissolve about a drachm of pulverized sulphate of copper, in a little boiling water, and an equal quantity of powdered muriate of ammonia in a separate vessel, in hot water. By mixing the contents of the two glasses, a quadruple salt will be formed, which gives a yellow colour to the solution while hot, and becomes green when cold.

89. If a flat bar of iron be hammered briskly on an anvil, its temperature will soon be so increased, that a piece of phosphorous laid upon it, would instantly be inflamed. This experiment is designed to show, that caloric may be evolved merely by percussion.

90. If a piece of bright silver be dipped in a solution of sulphate of copper, it will come out unchanged: but if the blade of a clean pen-knife, or any piece of *polished* iron, be dipped in the same solution, the iron will instantly put on the appearance of copper.

91. Take the piece of silver, employed in the last experiment, hold it in *contact with the iron*, and then in this situation, dip them into the same solution, and both will be covered with copper.

92. Melt together equal parts of copper and antimony, the one a yellow, the other a white metal, and the alloy that results from this mixture, will take the colour of the violet.

93. If the grey oxide of antimony be fused in a crucible, we procure a beautiful transparent glass, which is called the *glass of antimony*. This takes the colour of the hyacinth.

94. When antimony is well fused upon charcoal, and if at the moment when its surface is not covered with any particle of oxide, we throw it suddenly upon the ground, the globules, into which it divides in its fall, burn with a very lively flame, throwing out on all sides brilliant sparks, different from that of any other metal.

95. Dissolve dry nitrate of silver in pure water; add a little oil of turpentine, shake the mixture, and cork it close. Submit the phial, with its contents to the heat of boiling water for an hour, when the metal will be revived, and the inside of the phial, where the oil reposed on the aqueous solution, will be beautifully silvered, the revived metal forming a metallic ring, extending quite round the phial.

96. Immerse a slip of white silk in a solution of nitro-muriate of gold in distilled water, and dry it in the air. Silk thus prepared, will not be altered by hydrogen gas; but if another piece of silk be dipped in the solution, and exposed while *wet* to a current of hy-

drogen gas, instant signs of metallic reduction will appear; the colour will change from yellow to green, and a brilliant film of reduced gold will soon glitter on its surface.

97. Dissolve some chrystals of muriate of tin in distilled water, then dip a piece of white silk in the solution, and dry it in the air. If this be now immersed in hydrogen gas, no change will be observed; but if it be exposed while *wet* to the same current of gas, the reduction will soon commence, attended with a great variety of beautiful colours, as red, yellow, orange, green, and blue, variously intermixed.

98. If a bit of white silk be immersed in an etheral solution of gold, and dried, the application of phosphorized ether will only impart a brown colour to the silk; but if it be placed on the palm of the hand, as soon as the phosphorus begins to fume, and breathed on for a considerable time, the brown will be succeeded by a purple tinge, and the metallic lustre of the gold soon begin to appear.

99. With a needle pass a thread through a small bit of phosphorus, previously freed from moisture, by immersing it in alcohol. If this be suspended in an aqueous solution of nitro-muriate of gold, in a few minutes the phosphorus will become covered with gold.

100. If a piece of white silk be dipped in an aqueous solution of nitro-muriate of gold, and exposed while wet to sulphurous acid gas, the whole piece will in a few seconds, be covered with a coat of reduced gold, which remains permanent.

101. Dip a piece of white calico in an aqueous solution of acetate of lead, and then drop a little solution of sulphuret of potash upon it. If this be now placed in the palm of the hand, the lead will be observed gradually to revive, and will soon be reduced to its metallic state.

102. Dissolve some sulphuret of potash in alcohol, and immerse a slip of white silk in the solution. If a drop of an aqueous solution of sulphate of manganese be now applied, films of metallic manganese bright as silver, will instantly appear.

QUESTIONS

And other exercises on the foregoing summary of facts and experiments.

WHAT is the consequence of water being frozen?

What is the reason that deep lakes never freeze?

What are the effects of caloric upon metals?

What is the difference between expansion and fluidity?

What is meant by the term fusion?

What is meant by the term vitrification?

What is vapour, or steam?

In what manner is caloric diffused?

What are its effects upon water?

What bodies are most expanded by caloric?

Are bodies heavier when united with caloric?

What is the disposition of a heated body?

Are all substances equally susceptible of conveying caloric?

What is the object of chemistry?

How is a substance or body defined?

What is the difference between a simple and a compound body?

What is the meaning of the words analysis and synthesis, in chemistry?

By what kind of agency are substances analysed?

What is chemical affinity?

Enumerate the substances regarded by chemists as simple substances.

What is caloric or heat? What is light?

What is the most powerful chemical agent?

What is chemical mixture?

What is the difference between a mixture and a solution?

What is meant by the term *saturation?*

What is meant by the boiling and freezing points in the thermometer?

What degree of heat may be given to water?

Describe oxygen.

What are its effects on the metals?

Are oxides heavier than the metals which produce them?

Does heat operate in the same way upon all substances?

What is the difference between bodies that are combustible, and those that are not combustible?

Does water become hotter by being boiled in the common way?

What are the uses to which steam is applied?

Describe the effects of heat in the operation of evaporation, distillation, and sublimation.

On what principle does nitrogen gas extinguish flame?

How is oxygen gas obtained?

What proportion does oxygen form in the air we breathe?

What are the effects of oxygen gas in combustion?

What is nitrogen?

What is the proportion of nitrogen in the atmosphere? How is it procured?

What is the comparative weight of nitrogen gas

What are its effects when breathed?

What are its combinations with oxygen?

For what substances has oxygen a strong affinity?

What taste or character does oxygen give to bodies?

Does oxygen impart the acid character to every substance?

Does it combine with substances in an uniform or equal quantity?

What are the combinations of nitrogen gas and oxygen gas? What is the nature of nitrous oxide?

What is nitrous gas?

What is phosphuretted hydrogen gas?

What is carburetted hydrogen gas?

What is phosphorus?

What are its effects when exposed to the common air?

What is hydrogen? In what state is it found?

How is hydrogen gas obtained?

What is the comparative weight of hydrogen gas?

What are the effects of mixing hydrogen gas with common air?

What other substances, besides water, does hydrogen gas combine with?

What is sulphuretted hydrogen gas?

Is hydrogen gas inflammable?

Is it capable of supporting combustion of itself?

How are the gas lights obtained?

How is phosphoric acid formed?

What effects has phosphorus when taken into the stomach?

What is phosphate of lime? How is it obtained? In what substance does it exist? What is charcoal?

What are the properties of charcoal?

What is the nature of its attraction for oxygen?

What is sulphurous acid? What is sulphuric acid?

With what substances does sulphur unite?

What smell does it communicate to mineral waters?

In what substance is carbon supposed to exist in a state of purity?

In what combination is it most frequently met with?

In what substances is lime found in most abundance?

What is the chief ingredient of sea-shells?

Of what are the shells of eggs, and of snails, chiefly composed?

What is the manure called marl?

What is carbonic acid? What are carbonates?

What is carbonic acid gas?

What are the effects of breathing carbonic acid gas?

Where is carbonic acid gas found?

Explain the method of obtaining carbonic acid gas.

What are the earths?

Which of the simple earths are most abundant?

What is the chief ingredient of common coal?

What other substances does carbon form part of?

How does it combine with iron?

What name is given to these compounds of lime?

How is quick-lime procured? What is slaked lime?

What effect has heat upon metals?

What effect has oxygen upon them?

What name do they assume from this effect?

State the comparative weight of the metals.

Are they capable of transmitting light through them?

What is their most remarkable property?

What is silex? In what substance is silex found?

What is meant by the term malleability?
What is ittria? What is glucine?
What is zirconia?
On what account are the metals valuable?
What is plaster of Paris? What is alumine?
Of what are clays, and argillaceous earths composed?
What is strontites?
What are the properties of strontites?
What is the chief ingredient in gun-flints?
What are the rock chrystals composed of?
What is the earth, called *magnesia?* What is barytes?
To what uses are the metallic oxides applied?
What are the names and properties of the perfect metals?
Explain what is meant by soldering.
What is a metallic oxide?
Describe the process of reduction.
What is the chief property of gold as a metal?
What is a metallic solution?
What metals are found in a pure state?
What other substances besides oxygen, do the metals combine with?
What combinations of this description are most frequently met with?
Describe the appearances attending the solution of a metal in an acid.
What are the names of the malleable metals?
Enumerate the brittle mettles that may be easily fused.
Enumerate those that are with difficulty fused.
In what state are metals generally found?
What is an ore?
Where are ores of metals generally found?
Explain how a metal is procured from an ore.
What are the chief properties of silver?
Describe its uses in chemistry.
What name is given to the solution of silver?
Describe its properties.
What is the name of the acid which dissolves or oxidizes it? What is platinum?
Of what colour is it, and what is its malleability?
What are its other properties?

In what state is cinnabar found?
Does mercury unite with other metals?
What is an amalgam?
What are the chief properties of copper?
What are its appearances when exposed to heat?
What is the nature of *lunar caustic?*
How is the nitrate of silver decomposed?
What are the chief properties of mercury?
Under what circumstances can it be frozen, or rendered solid?
State the peculiar properties of iron.
To what extent is it malleable?
In what state is iron found?
How is it separated from its ore?
What is pig or cast iron?
What are the chief properties of tin?
Does it combine with other metals?
To what uses is copper applied in chemistry?
What are the metals which form brass?
Explain the effects of an acid upon copper.
State its combination with the metals.
Illustrate the alloy of copper with gold.
What is the chief ingredient in bronze and bell metal?
State the purposes of tinning other metals.
What are the remarkable properties of lead?
How is wrought iron made? How is steel made?
Enumerate the different kinds of steel, and explain how they are made.
What is green vitriol?
Illustrate its use in dyeing and in making ink.
In what substance is zinc found?
To what purposes is it applied?
What effects are produced by applying heat to it?
What is cobalt? In what state is it used?
Describe the substance called *smalts*, by painters.
In what state is arsenic found?
What are its effects in medicine?
What effects are produced when heat is applied to it?
When mixed with copper, what are its effects?
What is the result of its combinations with sulphur?

What are the properties of antimony?

To what purposes is it applied?

In what respects is bismuth remarkable?

In what state is it found?

What are the effects of mixing or alloying it with other metals?

What are the effects of oxygen upon lead?

Of what is pewter formed? Where is nickel found?

To what uses is it applied by the Chinese?

What is chrome? To what uses may it be applied?

Where is cobalt found?

In what state is manganese found?

Is it applied to any use as a metal?

What quantity of oxygen does it contain as an oxide?

To what purposes is oxide of manganese applied?

What is the most striking peculiarity of the alkalies?

What effect have they on the juices of vegetables?

How do they act, when mixed with oil and water?

How is soda procured?

What is common salt made of?

Where is soda found in a native state?

To what uses are potash and soda applied?

What are the two fixed alkalies?

What is the third alkali?

State the discoveries of Mr. Davy, respecting the alkalies.

How is potash procured?

In what substances is it found?

What is the nature of ammoniacal gas?

What is ammonia composed of?

In what state do animal and vegetable substances produce ammonia?

How is it procured?

In what countries is potash chiefly procured?

State the various names of soda.

What are the caustic alkalies?

What are the mild alkalies?

Describe the nature of ammonia.

How is sal ammonia prepared?

What are the uses of sal ammonia?

How many classes of acids are there?

How is sulphuric acid formed?
What are its properties?
What effects has sulphuric acid in the state of gas?
What are the effects of the oxymuriatic acid gas upon metals?
What is nitric acid?
What are the properties of nitric acid?
What are its effects on the metals?
What is the most frequent property of acids?
What effect have they upon the juices of vegetables?
What are the chemical compounds, called salts?
To what combination do the salts owe their origin?
What is the composition of fluoric acid?
To what uses is it applied?
What is boracic acid?
How is muriatic acid obtained?
Describe its effects in the state of gas.
Has it been as yet decompounded?
What are the salts, called muriates?
What is oxymuriatic acid?
What are its uses in bleaching?
How is the nitro-muriatic acid formed?
What are the component parts of carbonic acid?
What are the effects of carbonic acid gas when mixed with water?
With what substances does carbonic acid combine?
What are the carbonates?
State the composition of phosphoric acid.
What are its appearances when deprived of water?
In what substance is oxalic acid found?
To what purpose is oxalic acid applied?
What is tartarous acid? How is it obtained?
How is acetous acid obtained?
How is distilled vinegar obtained?
What is acetic acid? How are the acetates formed?
What are the properties of acetic acid?
To what purposes is it applied?
What is the citric acid? What is the mucous acid?
Describe the benzoic acid.
What is succinic acid?
Describe the manner in which it is obtained.

How is camphoric acid obtained?
What is prussic acid composed of?
How is it prepared? What is sebacic acid?
What is the definition of salts, in chemistry?
What is a super-carbonate?
What is a sub-carbonate?
What is the difference between salts terminating in *ite*, and in *ate*?
How is malic acid obtained?
To what purposes is it applied?
How is lactic acid formed?
What is gallic acid composed of?
What are the properties of gallic acid?
What is a neutral salt?
What is meant by the term sulphates?
What is meant by the term nitrates?
What is meant by the term carbonates?
What are the properties of the muriates?
Explain the effects of heat when applied to common salt.
Where are the muriates most generally met with?
What are the properties of the sulphates?
Enumerate the principal sulphates?
What is the nature of the sulphites?
What are the nitrates remarkable for?
What is the effect of pouring sulphuric acid upon the nitrates?
What is salt-petre?
Which is the most common carbonate?
What is glass of phosphorus?
What are the most common phosphoric salts?
Give the definition of an oxide.
What substances are capable of becoming oxides?
What are the most remarkable properties of the fluates?
Enumerate the fluates most commonly met with.
What is Derbyshire spar composed of?
In what substances is phosphate of lime found?
By what property are the acetates distinguished?
What are the chief acetic salts?
What is acetate of lead, and how is it formed?
What are the tartrites? What are the prussiates?

What degrees of affinity exist between the metals and oxygen?

In what state can a metal be dissolved in the acids?

What other substances besides the metals have their oxides?

Describe such bodies as are called combustible.

What are the simple combustibles?

What is oxide of sulphur?

What is oxide of phosphorus?

What substance is formed by hydrogen and oxygen?

What are compound combustibles?

How many incombustible substances are there?

What are the nitrous and nitric oxides?

How is nitrous oxide procured?

What are the properties and effects of nitrous oxide?

How is nitric oxide procured?

What are the effects of nitrous or nitrogen gas?

What is meant by the term combustion?

Explain the effects of oxygen upon combustion.

What combination is formed by nitrous or nitrogen gas with oxygen?

Describe the circumstances absolutely necessary before combustion can take place.

Whence is the heat derived during combustion?

What substances are called supporters of combustion?

Under what circumstances does hydrogen emanate from animal and vegetable substances?

When does water assume a solid form?

What is mineral water?

What is the difference between an oxide and an acid, formed by combustion?

What is the effect of combustion in forming new combinations of bodies?

How is water compounded? How decomposed?

Enumerate the simple substances which enter into the combination of vegatables.

What is the most frequent ingredient in vegetables?

In what substanees is gum, or mucilage, found?

What are the gums most used in chemistry?

From what substance is jelly procured?

In what vegetable substance is tan most abundant

What is tan remarkable for?

What is the common name of sulphate of magnesia?
What is the nature of chalybeate springs?
What substances are most common in mineral waters?
What kind of salts are most frequently found in mineral waters?
In what vegetables is the bitter principle most conspicuous?
In what substances is gluten and starch to be found?
Describe the method of obtaining gluten and starch.
In what state does oil exist in vegetables?
How are fixed vegetable oils obtained?
What is an essential or volatile oil?
What is albumen?
Describe the nature of camphor.
In what manner is wax formed?
How is resin produced?
What are the substances called resins?
What is Indian-rubber?
What is cork? What is gelatine?
How are essential distinguished from fixed oils?
What are the properties of the essential oils?
Enumerate the simple substances, of which animal bodies are compounded.
What is the most common ingredient in animal substances?
What is putrefaction?
What is the character of oils obtained from land animals?
Under what circumstances is phosphorus found in animal substances?
What are the bones of animals composed of?
What is butter? What is fermentation?
Describe the vinous fermentation.
In what kind of animal substance is sugar found?
What kinds of oils are found in animals?
What is spermaceti?
What is the character of fish-oil?
What is the clot, or thick part of blood composed of?
What composes the watery part of blood?
What is milk composed of?
What is the acetous fermentation?
In what manner is the sensation of cold produced?

Describe how a mild salt may be produced from two corrosive substances.

How is phosphorus treated, in order to produce instantaneous light, in the dark?

In what manner may water be frozen in the midst of summer?

How is inflamed phosphuretted hydrogen gas procured?

How are colours discharged from dyed linen, or cotton cloth?

Describe the method of writing on paper, with ink that becomes visible only when heated.

Describe how the metals are made to burn.

Describe the method of putting silver flowers upon silk riband.

Describe how oil and water may be made to unite.

Describe how to produce a solid substance, by the mixture of two fluids.

How is a transparent fluid produced from a solid substance?

How is carbonic acid detected in water?

Describe the method of obtaining sulphate of silver, and muriate of silver.

How may a landscape be painted, so as to appear as an outline only at first, but which afterwards assumes various colours?

What effect is produced by breathing into a tumbler full of lime water?

What is the vapour, produced by burning spirits of wine, composed of?

What is the effect of pouring solution of nitrate of copper upon tin-foil?

How is the metallic tree formed?

What is the production resulting from melting red-lead and charcoal together?

How is the paint called patent yellow produced? and what is its name in chemistry?

Describe the effects produced by shaking a mixture of sulphate of zinc, and liquid ammonia.

Describe the changes of colour produced in the tincture of red-cabbage, and how effected.

Describe the revivification of silver, from the nitrate of silver.

How is the colour called Prussian blue formed?

Under what circumstance does the union of two gases form a solid substance?

In what manner is silk coated with leaf-gold?

Describe the method of reviving the metals, when thin silk or calico is covered with oxides, or metallic salts?

What is the effect of dropping nitrate of silver into water containing some common salt?

In what manner may a continued motion be produced, which will last for several years?

Describe the electric column.

What kind of gas is the fire damp?

What late discovery has been made to prevent the dangerous effects of this air in mines?

Describe the *safe lamp*.

What is the best substance for obtaining carburetted hydrogen free from disagreeable effluvia?

What is the process for whitening linen by means of the oxymuriatic acid gas?

By what means is the suffocating odour of this gas so neutralized as to prevent injurious effects?

How is the gas rendered portable?

What is understood by attraction of cohesion?

What is simple affinity?

What is meant by attraction of gravitation?

What is compound affinity?

What objections have been offered to chlorine being considered a simple substance?

Do these objections apply to iodine and fluorine?

It has been latterly stated that hydrogen as well as oxygen produces acidity—Are there any objections to this opinion?

Silex has also latterly been considered as an acid—What objections are there to this idea?

What reasons are there for supposing that oxygen is the alone supporter of combustion?

A GLOSSARY OF TERMS

USED IN

CHEMISTRY.

A.

Acetic acid. The pure acid portion of vinegar.

Acetates. Salts formed by the combination of any base with the acetic acid.

Acids. Those bodies which produce the taste of *sourness.* In general they are liquids; some of them, however exist in a solid form.

—— *oxygenized.* Acids combined with an additional quantity of oxygen, for particular purposes.

Acid, acetous. The base of vinegar produced by a peculiar fermentation from vinous liquors.

—— *arsenic.* A compound of arsenic and oxygen.

—— *benzoin.* A vegetable acid obtained from benzoin.

—— *bombic.* An animal acid obtained from silk worms.

—— *boracic.* A peculiar acid obtained from borax.

—— *camphoric.* A vegetable acid obtained from camphor.

—— *carbonic.* A combination of carbon and oxygen.

—— *chromic.* A compound of chrome and oxygen.

—— *citric.* A vegetable acid obtained from lemons.

—— *fluoric.* A peculiar acid obtained from fluor spar.

—— *gallic.* A vegetable acid procured from galls.

—— *lactic.* An animal acid prepared from whey.

—— *malic.* A vegetable acid found in the juice of apples and several other fruits.

—— *molybdic.* A compound of molybdena and oxygen.

—— *mucous.* A vegetable acid obtained from gum arabic.

—— *muriatic.* Obtained from sea salt; its base is unknown.

—— *oxymuriatic.* Formed with muriatic acid and oxygen.

—— *nitric.* A compound of nitrogen and oxygen?

—— *oxalic.* A vegetable acid found in the juice of sorrel: it may also be obtained from vinegar and several other substances, by distillation with nitric acid

Acid phosphoric. A compound of oxygen and phophorus.
—— *prussic.* An animal acid, composed of hydrogen, nitrogen, and carbon.
—— *sebacic.* An animal acid obtained from fat.
—— *succinic.* A peculiar acid obtained from amber.
—— *sulphuric.* A compound of sulphur and oxygen.
—— *tartarous.* A peculiar acid found in the cream of tartar of commerce.

Aeriform fluids Fluid substances combined with an additional portion of caloric, sufficient to give them the form of gas, or vapour.

Affinity, chemical. A term used to express that peculiar propensity, which different species of matter have to unite with each other.
——— *of aggregation.* A force by which two bodies of the *same* kind tend to unite, and by which an aggregate is formed, without the *chemical* properties of the substances being at all changed.
——— *of composition.* A force by which substances of *different* kinds unite, and by which matter is formed, whose properties are different from those of the bodies before their combination. This attraction is stronger in proportion as the nature of the bodies is different, between which it is exerted. It is the same with chemical affinity.

Agate. A precious stone of the lowest class, almost transparent, and of a vitreous appearance.

Aggregates. Substances whose parts are united by cohesive and not by chemical attraction.

Alabaster. Sulphate of lime.

Albumen. It is that peculiar animal substance, which forms the cerum of the blood, the white of eggs, and other compounds.

Alchemy. The imaginary art of transmuting the baser metals to gold, also of furnishing an universal medicine and menstruum.

Alcohol. Rectified spirits of wine.

Alembic. The term formerly given to the still used by chemists for their distillation.

Alkalies. Peculiar substances which have a burning, and caustic taste, and a strong tendency to combination.

When united with acids, they form mild alkaline salts.

Alloys. A combination of any two metals, except mercury, is called an alloy Thus gold is alloyed either with silver or copper, for the purposes of coinage.

Alluvial. By alluvial depositions, is meant the soil which has been formed by the destruction of the mountains, and the washing down of their particles, by torrents of water.

Ammonia. The volatile alkali: In a pure state it always exists in an aëriform fluid of a pungent smell; with the muriatic acid it forms the sal ammoniac of commerce.

Amalgam. A combination or mixture of mercury with any other metal It is always soft, like butter.

Amber. A beautiful bituminous substance of a yellow or brown colour, which takes a good polish, and after a slight rubbing becomes electric. It was called *electrum* by the ancients, and hence the word *electricity.*

Amethyst. A gem of a violet colour and great brilliancy, said to be as hard as the sapphire or ruby, from which it only differs in colour.

Ammoniacal salts. Salts formed with ammonia.

Analysis. The resolution of a substance into its constituent parts, for the purpose of chemical examination.

Annealing. The art of rendering substances tough, which are naturally hard and brittle. Glass and iron are annealed by gradual cooling; brass and copper by heating, and then suddenly plunging them in cold water.

Antiseptic. Resisting putrefaction.

Apparatus, chemical. This term is descriptive of all the utensils made use of in a chemical laboratory. The principal are stills, furnaces, crucibles, retorts, receivers, matrasses, worm tubs, pneumatic troughs, thermometers, &c.

Apparatus, pneumatic. Such apparatus as are applied to operations on gaseous or aëriform fluids only.

Areometer. A graduated glass instrument with a bulb,

by which the weight or gravity of liquids are ascertained.

Argillaceous. A term descriptive of those earths which contain alumine or clay.

Aroma. A term used for the odour which arises from certain vegetables, or their infusions.

Arseniates. Salts formed by the combination of any substance, with the acid of arsenic

Asphaltum. A bituminous substance found in a soft or liquid state on the surface of the Dead Sea, which by age grows dry and hard It is also found in the earth in several parts of the world.

Atmospheres. This term is used to express the degree of additional pressure given to fluids. Thus, if in order to impregnate water with any of the gases, we give it a pressure of 15lbs. upon every square inch of surface, we are said to give it one atmosphere, if 30 lbs. two atmospheres, &c.

Attraction Chemical attraction is a term synonimous with *affinity:* which see.

Azote. See *Nitrogen.*

B

Balloon. A term given by the French to their spherical chemical receivers.

Balsams Certain aromatic resinous substances, which are obtained from trees by incision.

Barometer. An instrument which shows the variation of the pressure of the atmosphere, by the rise or fall of a column of mercury in a graduated glass tube.

Barytes. The most ponderous of the earths, whence its name.

Base. A chemical term, usually applied to denote the earth, the alkali, or the metal which is combined with an acid to form a salt.

Baths. Vessels for distillation, or digestion, contrived to transmit heat gradually and regularly.

Bath-sand. Vessels filed in part with dry sand, in which retorts are placed which require a greater heat than can be given by boiling water.

Bath-water. Vessels of boiling water, in which other vessels, containing the matters to be distilled or digested, are placed.

Benzoates. Salts formed by the combination of any base with the benzoic acid.

Beril. A variety of the emerald.

Bismuth. One of the metals, and the only one which has yet been had in a chrystalline state by art.

Bittern. The liquor which remains after the crystallization of muriate of soda (sea-salt). It generally contains sulphate of magnesia, and a small portion of sulphate of soda.

Bitumen. A generic term, applied to a variety of fossil inflammable substances, such as coal, &c.

Blowpipe. An instrument to increase and direct the flame of a lamp for the analysis of minerals, and for other chemical purposes.

Bolthead. A round chemical vessel with a long neck, usually employed for digestions. It is also called a matrass.

Borates. Salts formed by the combination of any base with the acid of borax.

Button. A name given to the small round piece of metal which is found at the bottom of a crucible, after a metallic ore, or an oxide of metal has been reduced, or melted.

C

Calamine. A native oxide of zinc.

Calomel. The mild muriate of mercury.

Calcareous. A chemical term formerly applied to describe chalk, marble, and all other combinations of lime with carbonic acid.

Calcination. The application of heat to saline, metallic or other substances; so regulated as to deprive them of moisture, &c. and yet preserve them in a pulverulent form.

Caloric. The chemical term for the matter of heat.

Calorimeter. An instrument for ascertaining the quantity of caloric disengaged from any substance that may be the object of experiment.

Calx. An old term used to decribe a metallic oxide.

Camphor. A peculiar vegetable substance extracted from the roots, wood, and leaves of two species of laurus. It is brought from China, Sumatra, and Borneo.

Camphorates. Salts formed by the combination of any base with the camphoric acid.

Caoutchouc, (termed *Indian rubber.*) A vegetable substance obtained from the milky juice of different plants in hot countries.

Capillary. A term usually applied to the rise of the sap in vegetables; or the rise of any fluid in very small tubes, by a peculiar kind of attraction, called capillary attraction.

Capsules. Small saucers of clay for roasting samples of ores, to ascertain their value.

Caputmortuum. A term signifying *dead head,* being that which remains in a retort after distillation to dryness. See *residuum,* which is the modern term.

Carbon. The basis of charcoal.

Carbonates. Salts formed by the combination of any base with carbonic acid.

Carburets. Compound substances, of which carbon forms one of the constituent parts. Thus plumbago, which is composed of carbon and iron, is called carburet of iron.

Causticity. That quality in certain substances, by which they burn or corrode animal bodies to which they are applied.

Cementation. A process by which metals are purified or changed in their qualities by heat, without fusion, by means of a composition, called a cement, with which they are covered. Thus iron by being kept a long time in a certain degree of heat, surrounded by charcoal powder, is converted into steel.

Ceruse. The white oxide of lead.

Chalybeate. A term employed to designate such mineral springs as owe their virtues to iron. The term refers to the early artizans who are stated to have been employed in the fabrication of this metal on the banks of the river Pontus: the *Chalybeans* (*Chalybes nudi,* see Virgil's Georgics.)

Charcoal. Wood burnt in close vessels: it is an oxide of carbon, and generally contains a small portion of salts and earth. Its carbonaceous matter may be converted by combustion into carbonic acid gas.

Chromates. Salts formed by the combination of any base with the chromic acid.

Chrysolite. A precious stone, which becomes electric by being rubbed. The chrysolite of the ancients was the same gem which is now called topaz.

Cinnabar. The red sulphuret of mercury.

Citrates. Salts formed by the combination of any base with citric acid.

Coal. A term applied to the residuum of any dry distillation of animal or vegetable matters.

Cohesion. A force inherent in all the particles of all substances, excepting light and caloric, and which prevents bodies from falling in pieces.

Cohobation. When a distilled fluid is poured again upon the matter from which it was distilled, in order to make it stronger, it is called cohobation.

Coke, or *Coak.* The residuum after the dispersion by heat of the volatile products of pit-coal in close vessels.

Cold. The negation of caloric. The temperatures of bodies, when diminished by artificial means, leave the impression of cold in proportion to the rapidity with which they abstract heat from the sentient living body in their neighbourhood. The absolute annihilation of the matter of heat would convert all aëriform and liquid matter to an inert, lifeless and frigid mass; chaos would come again. Caloric, the cause of warmth, is the great animator, and very soul of matter.

Coloration, of vegetables, is one of the most attractive phenomena of vegetation; it is a process analogous to oxidation.

Combination. A term expressive of a true *chemical* union of two or more substances, in opposition to mere mechanical mixture.

Combustibles. Certain substances which are capable of combining more or less rapidly with oxygen. They are divided by chemists into simple and compound.

Combustion. The act of absorption of oxygen, by combustible bodies, from atmospheric or vital air.

Comminution. The reduction of hard bodies into small

particles, by pounding, &c. Thus the heaviest substances may be made to float in the lightest fluids.

Composition. See *Synthesis.*

Compounds, may be binary, ternary, or quaternary, according as they are formed of two, three, or four elements.

Concentration. The act of increasing the specific gravity of bodies. The term is usually applied to fluids which are rendered stronger by evaporating a portion of the water which they contain.

Concretion. The art of converting liquids, or airs, or both, to a state of palpable solidity.

Condensation. The act of bringing the component parts of vapour, or gas, nearer together by pressure, or by colds. Thus atmospheric air may be condensed by pressure, and aqueous vapour by the subtraction of caloric, till it is converted into water.

Copperas. A sulphate of iron.

Cornelian. A variety of silex, with the oxide of iron.

Crucibles. Vessels of indispensable use in the various operations of fusion by heat. They are made of baked earth, or metal, in the form of an inverted cone.

Crystallization. An operation of nature, in which various earths, salts, and metallic substances pass from a fluid to a solid state, assuming certain determinate geometrical figures.

Crystallization, water of. That portion which is combined with salts in the act of crystallizing, and becomes a component part of them.

Cupel. A vessel made of burnt bones, mixed with a small proportion of clay and water. It is used whenever gold and silver are refined, by melting them with lead. The process is called cupellation.

Cupellation. All gold and silver wares are tried by this process, and marked in consequence in a peculiar way, to guard the public against frauds. Hence the term *cupel tests.*

D

Decombustion. Synonymous with deoxidation.

Decomposition. The separation of the constituent principles of compound bodies by chemical means.

Decrepitation. The sudden decomposition of salts, attended with a crackling noise when thrown into a red-hot crucible, or on an open fire.

Deflagration. The vivid combustion that is produced whenever nitre, mixed with an inflammable substance, is exposed to a red heat. This may be attributed to the extrication of oxygen from the nitre, and its being transferred to the inflammable body; as any of the nitrates or oxygenized muriates will produce the same effect.

Deliquesce. The tendency which some bodies have to become liquid by absorbing moisture from the atmosphere or elsewhere. Liquids of some kinds have also this property. Pure potash in a concrete state even deliquesces, and the sulphuric acid does the same; it is remarkable that their combination produces a salt, the sulphate of potash, which has no such property.

Deliquium. The state of potash, or any deliquescent salt, when it has so far deliquesced by exposure to the air, as to have become a liquid.

Deoxidate, or *deoxidize.* To deprive a body of oxygen.

Deoxidation. A term made use of by some writers to express that operation by which one substance deprives another of its oxygen.

Dephlegmate. To deprive any substance entirely of its water. It is a process the reverse of deliquescence.

Depuration. The purging or separating any liquid in a state of purity from its fæces or lees.

Desicate. To deprive of moisture any substance whether liquid or concrete. Explosion is consequent to the instantaneous conversion of solids into gases, or of gases into liquids or solids. *Gunpowder* elucidates the first process on being decomposed in close vessels; and the effect of kindling oxygen and hydrogen gases, the latter process.

Detonation. An explosion with noise. It is most commonly applied to the explosion of nitre when thrown upon heated charcoal.

Diamond. Carbon in a state of high purity, hitherto inimitable by art, though we are probably on the verge

of accomplishing this lovely operation of nature.

Digester. An instrument by means whereof the boiling point of water may be elevated far beyond 212°, when it becomes a solvent of many substances, which could not by ordinary decoction be liquified.

Digestion. The effect produced by the continued soaking of a solid substance in a liquid, with the application of heat.

Digestor, Papin's. An apparatus for reducing animal or vegetable substances to a pulp or jelly expeditiously.

Distillation. A process for separating the volatile parts of a substance from the more fixed, and preserving them both in a state of separation.

Docimacy. The art of assaying the ores of metals.

Ductility. A quality of certain bodies, in consequence of which they may be drawn out into wire without fracture.

Dulcification. The combination of mineral acids with alcohol. Thus we have dulcified spirit of vitriol, &c.

Dyeing. The art of transferring the colouring matter of one body to another, so that it shall be durably fixed. It depends on the exertion of particular affinities between the colouring matters and the substances to which they are applied, (PARKINSON), which is accomplished however in most instances by the means of mordants only.

E

Ebulition, Is always attended by the conversion of a liquid into an elastic fluid, as water into steam. The temperatures at which liquids boil is influenced by atmospheric pressure, therefore the boiling point of fluids varies as the weight of the incumbent atmosphere. See *Digester.*

Edulcoration. Expressive of the purification of a substance by washing with water.

Effervescence. An intestine motion which takes place in certain bodies, occasioned by the sudden escape of a gaseous substance.

Efflorescence. A term commonly applied to those saline crystals, which become pulverulent on exposure

to the air, in consequence of the loss of a part of the water of crystallization.

Efflux. The spontaneous oozing of the juices of vegetables by incision or otherwise.

Elasticity. A force in bodies, by which they endeavour to restore themselves to the posture from whence they were displaced by any external force.

Elastic fluids. A name sometimes given to vapours and gases. Vapour is called an *elastic* fluid; gas, a *permanently* elastic fluid.

Elective. A name applied to chemical attraction, whereby various bodies having an affinity to any particular substance, and being presented to it in a mixed state, it unites with one and rejects all the rest. The term is less used than formerly, as it would appear to imply volition on the part of inanimate matter.

Elective attractions. A term used by Bergman and others, to designate what we now express by the words chemical affinity.

Elutriation. The operation of pulverizing metallic ores or other substances, and then mixing them with water, so that the lighter parts which are capable of suspension may be poured off.

Electricity. A property in bodies whereby when rubbed, they draw substances, emit flame, and may be filled with such a quantity of the electric fluid as if discharged at once upon a human body would endanger life. *Johnson.*

Elements. The simple, constituent parts of bodies, which are incapable of decomposition; they are frequently called principles. See "Simple Substances."

Eliquation. An operation whereby one substance is separated from another by fusion. It consists in giving the mass a degree of heat that will make the more fusible matter melt or flow, and not the other.

Emerald. A transparent precious stone of a green colour, nearly of the same hardness as the garnet or agate, but inferior to the topaz and ruby.

Emery. An ore of iron.

Empyreuma. A peculiar and indescribably disagreeable smell, arising from the burning of animal and vegetable matter in close vessels.

Enamels. Their tints are owing to the fixation of oxygen in the metallic oxides employed in the process.

Epsom Salt. Sulphate of magnesia.

Eolipile. A copper vessel with a small orifice, and partly filled with water. It is made hot, that the vapour of the water may rush out with violence, and carry a stream of air with it to increase the intensity of fire.

Essences. What are called essences, in chemistry and pharmacy, are the essential oils obtained by distillation from odoriferous vegetable substances.

Essential salts. The saline substances found in plants, and which are held in solution by the water wherein they are infused. They are obtained by evaporation and cooling.

Ethers. Volatile liquids formed by the distillation of some of the acids with alcohol.

Etching. The art of corroding copper, lead, or glass, by suitable chemical agents.

Etiolation. The blanching of vegetables by preventing the access of light.

Eudiometer. An instrument invented by Dr. Priestley, for determining the purity of any given portion of atmospheric air. The science of investigating the different kinds of gases, is called *eudiometry.*

Evaporation. The conversion of fluids into vapour by heat.

Expression. A term used in pharmacy, denoting the act of forcing out the juices and oils of plants by means of a press. By a similar term, the *expressed* are distinguished from the *essential* oils.

Exsiccation. The act of drying moist bodies. It is effected two ways; by exhaling the aqueous particles by the application of heat or atmospheric air, or by absorbing the moisture with soft and spongy substances.

Extracts. The soluble parts of vegetable substances, first dissolved in spirit or water, and then reduced

to the consistence of a thick syrup, or paste, by evaporation.

F

Farina, or flour. A species of fecula.

Fat. An oily concrete animal substance, composed of sebacic acid, and carbon.

Fecula, vegetable, differs from mucilage only in being insoluble in cold water, in which liquid it falls very speedily; by caloric or in hot water, it assumes all the properties of mucilage. Paper is a fæcula. Indigo has been termed a colouring fæcula.

Fermentation. A peculiar spontaneous motion, which takes place in all vegetable matter when exposed for a certain time to a proper degree of temperature.

Fibrin is that white fibrous substance left after *elutriation* of the coagulum of blood, and which also composes the principal part of the animal fibre. It shrivels like parchment on exposure to heat. It has been thought to be the seat of irritability, and the medium by which the energies of life are directed to the several organs.

Filtration. A chemical process for the purifying of liquid substances. Blotting paper supported by a funnel, is commonly made use of; but for expensive liquors, chemists generally use a little carded cotton, lightly pressed into the tube of a glass funnel.

Fire. That appearance produced from the combined effects of light and heat, at the same time disengaged in the act of combustion.

Fixity. A term applicable to the property of some bodies of bearing a great heat without being volatilized.

Flowers, in chemical language, are solid dry substances reduced to a powder by sublimation Thus we have flowers of arsenic, of sal ammoniac, of sulphur, &c. which are these substances unaltered, except in appearance.

Fluates. Salts formed by the combination of any base with fluoric acid.

Fluidity A term applied to all liquid substances. Solids are converted to fluids by combining with a certain portion of caloric.

Flux. A substance which is mixed with metallic ores,

or other bodies, to promote their fusion; as an alkali is mixed with silex, in order to form glass.

Fossil. See *Mineral*, with which it is synonimous.

Freezing. The *point* at which water assumes a crystalline form.

Fuliginous. A term sometimes made use of in describing certain vapours which arise in chemical operations, having the thick appearance of smoke.

Fulmination. Thundering, or explosion with noise. We have fulminating silver, fulminating gold, and other fulminating powders, which explode with a loud report by friction, or when slightly heated.

Furnaces. Vessels of various forms for the fusion of ores, or other operations which require heat.

———, *blast.* Are built for making iron, smelting ores, &c. They are so contrived that their heat is much increased by means of powerful bellows. A blacksmith's forge is a kind of blast furnace.

———, *wind.* Chemical furnaces for intense heat, so constructed, that they draw with great force, without the use of bellows.

Fusion. The state of a body which was solid in the temperature of the atmosphere, and is now rendered fluid by the artificial application of heat.

G

Galena, or the black ore of lead. This, which is the most common of all lead ores, is frequently distinguished by the name of potter's lead ore.

——— An ore of zinc, known in the English mine countries, by the name of black jack, or mock lead.

Gallates. Salts formed by the combination of any base with gallic acid.

Galvanism. Supposed to be essentially the same principle as electricity.

Garnet. A stone which when transparent and of a fine colour is reckoned among gems.

Gas. All solid substances when converted into permanently elastic fluids by caloric, are called gases.

Gases are then of necessity compounds formed by the union of a base, with a sufficient portion of the matter of heat.

Gaseous. Having the nature and properties of gas.
Gazometer. A name given to a variety of utensils and apparatus, contrived to measure, collect, preserve, or mix the different gases.
Gelatine. A chemical term for animal jelly or glue. It exists particularly in the tendons and the skin of animals.
Glass. Some metallic oxides, when fused, are called *glass.* They have somewhat of resemblance to common glass.
Glass, phosphoric. A vitreous, insipid, insoluble substance, procured by boiling down phosphoric acid to a syrup, and then melting it by an increased heat.
Glucine. A peculiar earth which has been found in emerald and beryl.
Gluten. A vegetable substance somewhat similar to animal gelatine or glue. It is the gluten in wheat flour which gives it the property of making good bread, and adhesive paste.
Grain. The *smallest* weight made use of by chemical writers. Twenty grains make a scruple; 3 scruples a drachm; 8 drachms, or 480 grains, make an ounce; 12 ounces, or 5760 grains, a pound troy. The *avoirdupois* pound contains 7000 grains.
Granite. A compound rock consisting of quartz, feltspar and mica.
Granulation. The operation of pouring a *melted* metal into water, in order to divide it into small particles, for chemical purposes. Tin is thus granulated by the dyers before it is dissolved in the proper acid; and lead also in the same way in order to make small shot.
Gravity. That property by which bodies move towards each other, in proportion to their respective *quantities* of matter. This is the property by which bodies fall to the earth.
Gravity, specific. This differs from absolute gravity in as much as it is the weight of a given *measure* of any solid or fluid body, compared with the *same measure* of distilled water.
Gum. Mucilaginous exudations from certain trees.

Gum consists of lime, carbon, oxygen, hydrogen, and nitrogen, with a little phosphoric acid.

H

Heat. See *Caloric.*

Hepar, or *Liver.* The name formerly given to the combination of sulphur with alkali. It is now called sulphuret of potash, &c. instead of liver of sulphur.

Hepatic Gas. The old name for sulphuretted hydrogen gas.

Hermetically. A term applied to the closing of the orifice of a tube, or vessel, so as to render it air-tight. —It is usually done by melting the end of the tube by means of a blow-pipe.

Horn-silver. Luna cornua, the muriate of silver.

Hyacinth. A precious stone of an orange red, nearly as hard as rock crystal.

Hydrogen. A simple substance; one of the constituent parts of water.

——— *gas.* Solid hydrogen united with a large portion of caloric. It is the lightest of all the known gases. It was formerly called inflammable air.

Hydrometers. Instruments for ascertaining the specific gravity of spiritous liquors, or other fluids.

Hygrometers. Instruments for ascertaining the degree of moisture in atmospheric air.

Hyperoxygenized. A term applied to substances which are combined with the largest possible quantity of oxygen. We have muriatic acid, oxygenized muriatic acid, and hyperoxygenized muriatic acid.

I

Ice. The crystalline form of water.

Incaudescence, imports a *white heat.*

Incineration. The burning of vegetables for the sake of their ashes. It is usually applied to the burning of kelp, for making alkali or soda.

Inflammation. A phenomenon which takes place on mixing certain substances. The mixture of oil of turpentine with strong nitrous acid, is an instance of this peculiar chemical effect.

Infusion. A simple operation to procure the salts, juices, and other virtues of vegetables, by means of water.

Ink, Sympathetic, (green), the *muriate of cobalt.*

Integrant particles. The most minute particles into which any substance can be divided similar to each other, and to the substance of which they are parts, are termed its integrant particles.

Intermediates. A term made use of when speaking of chemical affinity. Oil, for example, has no affinity to water, unless it be previously combined with an alkali; it then becomes soap, and the alkali is said to be the *intermedium* which occasions the union.

K

Kali. A genus of marine plants, which is burnt to procure mineral alkali by afterwards lixiviating the ashes.

L

Laboratory. A room fitted up with apparatus for the performance of chemical operations.

Lac. A resin, and not, as improperly termed, a gum.

Lactates. Salts formed by the combination of any base with lactic acid.

Lakes. Certain colours made by combining the colouring matter of cochineal, or of certain vegetables, with pure alumine, or with oxide of tin, zinc, &c.

Lamp, Argand's. A kind of lamp much used for chemical experiments. It is made on the principles of a wind furnace, and thus produces a great degree of light and heat, without smoke.

Lens. A glass, convex on both sides, for concentrating the rays of the sun. It is employed by chemists in fusing refractory substances which cannot be operated upon by an ordinary degree of heat.

Levigation. The grinding down of hard substances to an impalpable powder on a stone with a muller, or in a mill adapted to the purpose.

Liquefaction. The change of a solid to the state of a fluid, occasioned by the combination of caloric.

Litharge. An oxide of lead which appears in a state of vitrification. It is formed in the process of separating silver from lead.

Lixiviation. The solution of an alkali or a salt in water, or in some other fluid, in order to form a lixivium.

Lixivium. A fluid impregnated with an alkali or with a salt.

Lute. A composition for closing the junctures of chemical vessels to prevent the escape of gas or vapour in distillation.

M

Maceration. The steeping of a solid body in a fluid in order to soften it, without impregnating the fluid.

Magistery. The precipitated or sublimed oxides of certain metals were so termed by the alchemists. As for example, *pearl white* is the magistery of bismuth.

Malates. Salts formed by the combination of any base with the malic acid.

Malleability. That property of metals which gives them the capacity of being extended and flattened by hammering. Or, the flexible or elastic nature induced in various metals, by annealing. It is contradistinguished with *brittleness.*

Manna. A sort of sugar.

Marble. Carbonate of lime.

Marcasite. Native sulphuret of iron, or pyrites.

Marl. Compounds of carbonate of lime and sand, or clay, or both. It differs from lime-stone by becoming diffused when blended with water equally as clay would; hence it is a carbonate of lime, in such a state, as to yield an impalpable powder, without exposure to the furnace, or lime-kiln.

Manganese. Probably a corruption of *magnes*, the loadstone, because of its property of destroying or neutralizing the colouring matter of glass. The black oxide of this metal is the magnet, (*manganese*) of the glassmakers. It is true, that in a minute portion added to alkali in solution, it becomes changed to blue, or if iron be present, to green. With much water it becomes violet and red, and afterwards the coloured particles will precipitate, and change to black. Hence the *mineral chamæleon,* so termed.

Massicot. A name given to the *yellow* oxide of lead, as minium is applied to the *red* oxide.

Matrass. Another name for a *bolt-head,* which see.

Matrix. The bed in which a metallic ore is found.

Menstruum. The fluid in which a *solid* body is dissolved. Thus water is a menstruum for salts, gums, &c. and spirit of wine for resins.

Mephitis. Nitrogen or azotic gas.

Metallic oxides. Metals combined with oxygen. By this process they are generally reduced to a pulverulent form; are changed from combustible to incombustible substances, and receive the property of being soluble in acids.

——— *irritation.* The energy of galvanism upon the nervous fibre.

——— *sulphurets* are abundant in nature; they imply compounds of sulphur and metallic bases only.

——— *alloys.* Compounds of metals. The chemical union of two or more metals is so called. Instances are numerous. All the amalgams are referrable to this head:—bell-metal, brass, bronze, gun-metal, latten, pinchbeck, princes'-metal, similor, and tombac, are of this kind.

Mica. A stone which in its purest state is colourless, but either from a less intimate combination, or from mixture of foreign substances, is found of different colours; the white and yellow of which have a metallic appearance, but not greasy to the touch, which distinguishes it from talc.

Mineral. Any natural substance of a metallic, earthy, or saline nature, whether simple or compound, is deemed a mineral.

Mineralizers. Substances which are combined with metals in their ores are sometimes termed mineralizers; as sulphur, arsenic, carbonic acid, &c.

Mineralogy. The science of fossils and minerals.

Mineral waters. Waters which hold some metal, earth, or salt in solution. They are frequently termed medicinal waters.

Minium. The red oxide of lead.

Molecule. The molecules of bodies are those ultimate particles of matter which cannot be decomposed by any chemical means.

Molybdates. Combinations of the molybdic acid and different bases. The Carynthian molybdate of lead is a specimen of native *yellow lead ore.*

Mordants. Substances which have a chemical affinity for particular colours: they are employed by the dyers as a bond to unite the colour with the cloth intended to be dyed.

Mother waters, or *Mothers*. The liquors which are left after the crystallization of any salts.

Mucilage. A glutinous matter obtained from vegatables, transparent and tasteless, soluble in water, but not in spirit of wine. It chiefly consists of carbon and hydrogen, with a little oxygen.

Muffle. A semi-cylindrical utensil, resembling the tilt of a boat, made of baked clay; its use is that of a cover to cupels in the assay furnace, to prevent the charcoal from falling upon the metal, or whatever is the subject of experiment.

Muriates. Salts formed by the combination of any base with muriatic acid.

N

Natron. One of the names for mineral alkali, or soda.

Nectar. The aromatic and saccharine juices of plants, from which honey is formed.

Neutralize. When two or more substances mutually disguise each other's properties by being in equal proportions, or by saturating each other, they are said to be neutralized.

Neutral-salt. A substance formed by the union of an acid with an alkali, an earth, or a metallic oxide, in such proportions as to saturate both the base and the acid.

Nitrates. Salts formed by the combination of any base with nitric acid.

Nitrogen. A simple substance, by the French chemists called *azote*. It enters into a variety of compounds, and forms more than three parts in four of atmospheric air.

Nomenclature. The language of chemical science.—The names of compounds are calculated to shew the kind and nature of the bodies which compose them. It admits of nothing arbitrary, and is capable of adaptation to future discoveries. The history of salts in general mark its many advantages over the arbitrary language of the old chemists.

O

Ochres. Various combinations of the earths with oxide, or carbonate of iron.

Oil. A fluid substance well known. It is composed of hydrogen, oxygen, and carbon.

Opal. A precious stone, which is the most beautiful of all the flint kind, owing to the changeable appearance of its colours by reflection and refraction.

Ores. Metallic earths, which frequently contain several extraneous matters, such as sulphur, arsenic, &c.

Organic compounds, are distinguished from factitious chemical products, by having had, or possessing vitality.

Orpiment. The yellow sulphuret of arsenic.

Oxalates. Salts formed by the combination of any base with oxalic acid.

Oxide. Any substance combined with oxygen, in a proportion not sufficient to produce acidity.

Oxidize. To combine oxygen without producing acidity.

Oxidizement. The operation by which any substance is combined with oxygen, in a degree not sufficient to produce acidity.

Oxygen. A simple substance composing the *greatest* part of water, and part of atmospheric air.

——— *gas.* Oxygen converted to a gaseous state by caloric. It is also called vital air. It forms nearly one fourth of atmospheric air.

Oxygenize. To acidify a substance by oxygen. Synonymous with Oxygenate.

P

Paper. Its chemical analysis affords the same products as fæcula.

Particles, are either *constituent* or *integrant.* The former are not farther decomposable by chemical means; the latter are the infinitely small molecules, into which compounds are mechanically divisible; but integrant particles themselves, consist of constituent particles, into which it is presumed they are separable by decomposition.

Parting. The operation of separating gold from silver, by means of nitrous acid, and other mediums.

Pellicle. A thin skin which forms on the surface of saline solutions and other liquors, when boiled down to a certain strength.

Percussin. The act of striking a body.

Petrifaction. When a mineral water holding earthy matter in solution, is dissipated, or loses the power by which such mineral matter is suspended, the earth is gradually deposited, and if it falls upon vegetable matters, encrusts and envelopes them so, as in due time to have the appearance of stone.

Petroleum. Liquid bitumen.

Phlogiston. An old chemical name for an imaginary substance, supposed to be a combination of fire with some other matter, and a constituent part of all inflammable bodies, and of many other substances.

Phosphates. Salts formed by the combination of any base with phosphoric acid.

Phosphites. Salts formed by the combination of any base with phosphorous acid.

Phosphorus. A concrete combustible body. It has its name from its spontaneous combustion with light, at the lowest known temperature, when exposed to the air of the atmosphere.

Phosphori of Baldwin, has the property of emitting light in the dark, after being heated. It is the nitrate of lime.

Phosphorus, Bolognian, has the same qualities. It is the sulphate of barytes.

Phosphurets. Substances formed by an union with phosphorus. Thus we have phosphuret of lime, phosphuretted hydrogen, &c.

Plumbago. Carburet of iron, or the *black-lead* of commerce.

Pneumatic. Any thing relating to the airs and gases.

———— *trough.* A vessel filled in part with water or mercury, for the purpose of collecting gases, so that they may be readily removed from one vessel to another.

Precipitate. Any matter which, having been dissolved in a fluid, falls to the bottom of the vessel.

Precipitation. That chemical process by which bodies

dissolved, mixed, or suspended in a fluid, are separated from that fluid, and made to gravitate to the bottom of the vessel.

Principles of bodies. Synonymous with *Elements;* which see.

Prussiates. Salts formed by the combination of any base with prussic acid.

Pulverization. The reducing of any body to powder, or overcoming mechanically the attraction of cohesion to a considerable extent.

Purification. The separation of all foreign matter from any substance or preparation, whether simple or compound.

Putrefaction. The last fermentative process of nature, by which bodies are decomposed so as to separate their principles, for the purpose of re-uniting them by future attractions, in the production of new compositions.

Pyrites. An abundant mineral found on the English coasts and elsewhere. Some are sulphurets of iron, and others sulphurets of copper, with a portion of alumine and silex.

Pyrites, martial. That species of pyrites which contains iron for its basis.

Pyrometer. An instrument invented by Mr. Wedgewood for ascertaining the degrees of heat in furnaces and intense fires.

Pyrophori. Substances which readily take fire, even spontaneously, on exposure to a dampish atmosphere, but not to perfectly dry air.

Q

Quartation. A term used by refiners in a certain operation of parting.

Quartz. A name given to a variety of siliceous earths, mixed with a small portion of lime, or alumine.

R

Radicals. A chemical term for the *Elements* of bodies; which see.

Radicals, compound. When the base of an acid is composed of two or more substances, it is said that the acid is formed of a *compound* radical.

Reagents Substances which are added to mineral waters, or other liquids, as tests to discover their nature and composition.

Realgar. Red sulphuretted oxide of arsenic.

Receivers. Globular glass vessels adapted to retorts for the purpose of preserving and condensing the volatile matter raised in distillation.

Rectification. Is the re-distilling a liquid to render it more pure, or more concentrated, by abstracting only a part.

Reduction. The restoration of metallic oxides to their original state of metals, which is usually effected by means of charcoal and fluxes.

Refining. The process of separating the perfect metals from other metallic substances, by what is called cupellation.

Refractory. A term applied to earths or metals, that are either infusible, or that require an extraordinary degree of heat to change or melt them.

Refrigeration. A method of crystallizing salts.

Refrigeratory. A contrivance of any kind, which, by containing cold water, answers the purpose of condensing the vapour or gas that arises in distillation. A worm-tub is a refrigeratory.

Registers. Openings in chimneys, or other parts of chemical furnaces, with sliding doors, to regulate the quantity of atmospheric air admitted to the fire-place.

Regulus. Signifies a pure metallic substance, freed from all extraneous matters.

Repulsion. A principle whereby the particles of bodies are prevented from coming into actual contact.

Residuum. What is left in a pot or retort after the more valuable part has been drawn off. Thus the sulphate of potash which remains in the pot after the distillation of nitrous acid, is called the residuum. It is sometimes called the *caput mortuum.*

Resins. Vegetable juices concreted by evaporation either spontaneously or by fire. Their characteristic is solu-

bility in alcohol, and not in water.—They owe their solidity chiefly to their union with oxygen.

Retort. A vessel in the shape of a pear, with its neck bent downwards, used in distillation; the extremity of which neck fits into that of another bottle, called a receiver.

Reverberatory. An oven or furnace in which the flame is confined by a dome which occasions it to be beat down upon the floor of the furnace before it passes into the chimney.

Revivification. See *Reduction,* which is a synonymous term; though "revivification" is generally used when speaking of quicksilver.

Roasting. A preparative operation in metallurgy to dissipate the sulphur, arsenic, &c. with which a metal may be combined.

Rockcrystal. Crystallized silex.

Rust. As of iron, is the oxide of this metal. The ordinary rust of iron, is the sub-carbonated oxide of that metal. Rust is, however, a general term for what is properly known by the name of metallic oxide.

Ruby. A precious stone of which there are several varieties. Of these the sapphire is the hardest and held in the highest estimation. The red sapphire when perfect is more valuable than a diamond of the same size.

S

Sacharum Saturni. The old name for the acetate of lead.

Salifiable bases. All the metals, alkalies, and earths, which are capable of combining with acids, and forming salts, are called salifiable bases.

Saline. Partaking of the properties of a salt.

Salts, neutral. A class of substances formed by the combination or saturation of an acid with an alkali, an earth, or other salifiable base.

Salts, triple. Salts formed by the combination of an acid with two bases or radicals. The tartrate of soda and potash (Rochelle salt) is an instance of this kind of combination.

Sand bath. } See *Bath*.
—— *heat.* }

Sandiver. A matter, composed of different salts, which rises as a pellicle on the surface of the pots in which glass is melted. It is used as a flux in the fusion of ores, and for other purposes.

Sap-colours. A name given to various expressed vegetable juices of a viscid nature, which are inspissated by slow evaporation for the use of painters, &c.; sap-green, gamboge, &c. are of this class.

Sapphire. A species of the ruby.

Saponaceous. A term applied to any substance which is of the nature or appearance of soap.

Saturation. The act of impregnating a fluid with another substance, till no more can be received or imbibed. A fluid which holds as much of any substance as it can dissolve, is said to be saturated with that substance. A solid body may in the same way be saturated with a fluid.

Selenite. A salt existing in spring water, formed by sulphuric acid and lime. Its proper chemical name is Sulphate of lime.

Semi-metal. A name formerly given to those metals which are neither malleable, ductile, nor fixed, if exposed to the fire.

Siliceous earths. A term used to describe a variety of natural substances, which are composed chiefly of silex; as quartz, flint, sand, &c.

Simple substances. Synonymous with *Elements;* which see.

Smelting. The operation of fusing ores for the purpose of separating the metals they contain, from the sulphur and arsenic with which they are mixed, and also from other heterogenous matter.

Solubility. A characteristic of most salts. See *Solution.*

Solution. The perfect union of a solid substance with a fluid. Salts dissolved in water are proper examples of solution.

Spars. A name formerly given to various crystallized stones; such as the fluor, or Derbyshire spar, the adamantine spar, &c.

Specific gravity. See the word *Gravity.*

Spelter. The commercial name of *zinc.*

Spirit. A term used by the early chemists to denote all volatile fluids, collected by distillation.

Spirit proof. A term made use of to describe such ardent spirits as are of the same strength as good brandy.

Stalactites. Certain concretions of calcareous earth found suspended like icicles in caverns. They are formed by the oozing of water through the crevices, charged with this kind of earth.

Steatites. A kind of stone composed of silex, iron, and magnesia. Also called French chalk, Spanish chalk, and soap-rock.

Sublimation. A process whereby certain volatile substances are raised by heat, and again condensed by cold into a solid form. Flowers of sulphur are made in this way. The soot of our common fires is a familiar instance of this process.

Sublimate. A name given to several mercurial preparations.

Subsalts Salts with less acid than is sufficient to neutralize their radicals.

Sugar. A well known substance, found in a variety of vegetables, composed of oxygen, hydrogen, and carbon.

Sulphates. Salts formed by the combination of any base with the sulphuric acid.

Sulphites. Salts formed by the combination of any base with sulphurous acid.

Sulphurets. Combinations of alkalies, or metals, with sulphur.

Sulphuretted. A substance is said to be sulphuretted when it is combined with sulphur. Thus we say, sulphuretted hydrogen, &c.

Super salts. Salts with an excess of acid.

Synthesis. When a body is examined by dividing it into its component parts, it is called analysis; but when we attempt to prove the nature of a substance by the union of its principles, the operation is called synthesis.

Syphon. A bent tube used by chemists for drawing liquids from one vessel into another. It is sometimes called a *Crane.*

T

Tartrates. Salts formed by the combination of any base with the acid of tartar.

Talc. A stone of a white gray, yellowish or greenish colour. It is soft and soapy to the touch, and is composed of very thin semi-transparent plates much tenderer and more brittle than mica.

Tan or *Tannin.* A vegetable principle found in large quantities in the bark of oak trees. It obtained that name from its use in the tanning of leather.

Temperature. The absolute quantity of caloric which is attached to any body, occasions the degree of temperature of that body.

Tenacity. Is a term used when speaking of glutinous bodies. It is also expressive of the adhesion of one substance to another.

Test. That part of a cupel which is impregnated with litharge in the operation of refining lead. The name of whatever is employed in chemical experiments to detect the several ingredients of any composition.

Test-papers. Papers impregnated with certain chemical re-agents; such as litmus, turmeric, radish, &c. They are used to dip into fluids to ascertain by a change of colours the presence of acids and alkalies.

Thermometer. An instrument to show the relative heat of bodies. Fahrenheit's thermometer is that used in England.

Tincal. The commercial name of crude borax.

Topaz. A species of precious stone, among the varieties of which some are rendered electric by heat, others by mere friction.

Tincture. Solutions of substances in spirituous menstrua, or solvents.

Torrefaction. An operation similar to *roasting;* which see.

Tourmalin. A precious stone more or less transparent, and generally of a shining black: like topaz it is rendered electric by heat.

Transmutation. A favourite term among the Alchemists, signifying the changing of one metal to another, which they supposed possible.

Trituration. A chemical operation whereby substances are united by friction. Amalgams are made by this method.

Tubulated. Retorts which have a hole at the top for inserting the materials to be operated upon, without taking them out of the sand heat, are called tubulated retorts.

Tutenag, (vulgarly called tooth and egg metal.) An Indian name for zinc. Chinese copper is also called by this name, which is a compound of copper, tin, and arsenic, much resembling silver in colour.

V

Vacuuum. A space occupied by matter. The term is generally applied to the exhaustion of atmospheric air, by chemical or philosophical means.

Vapour. This term is used by chemists to denote such exhalations only as can be condensed and rendered liquid again at the ordinary and atmospheric temperature, in opposition to those which are permanently elastic.

Vats. Large chemical vessels, generally of wood, for making infusions, &c.

Vital air. Oxygen gas.

Vitrification. When solid substances have undergone very intense heat, so as to be fused thereby, they frequently have an appearance resembling glass. They are then said to be vitrified; or to have undergone vitrification.

Vitriols. A class of substances, either earthy or metallic which are combined with the vitriolic acid. Thus there is vitriol of lime, vitriol of iron, of copper, &c. These salts are now called Sulphates, because the acid which forms them is called sulphuric acid.

Vitriolated Tartar. The old name for sulphate of potash.

Volatile alkali. Another name for ammonia.

Volatile salts. The commercial name for carbonate of ammonia.

Volatility. A property of some bodies, which disposes

them to assume the gaseous state. This property seems to be owing to their affinity for caloric.

Volume. A term made use of by modern chemists to express the space occupied by gaseous or other bodies.

Union, chemical. When a mere mixture of two or more substances is made, they are said to be mechanically united; but when each or either substance forms a component part of the product, the substances have formed a *chemical* union.

W

Wadd. The name given by miners to plumbago or carburet of iron, known in common by the very improper name of black lead.

Water. The most common of all fluids, composed of 85 parts of oxygen, and 15 of hydrogen.

——— *mineral.* Waters which are impregnated with mineral and other substances, are known by this appellation. These minerals are generally held in solution by carbonic, sulphuric, or muriatic acid.

Way, dry. A term used by chemical writers when treating of analysis or decomposition. By decomposing in the dry-way, is meant, by the agency of fire.

Way, humid. A term used in the same manner as the foregoing, but expressive of decomposition in a fluid state, or by means of water, and chemical re-agents, or tests.

Welding heat. That degree of heat in which two pieces of iron, or other metal, may be united by hammering.

Worm-tub. A chemical vessel with a pewter worm fixed in the inside, and the intermediate space filled with water. Its use is to cool liquors during distillation. See *Refrigeratory.*

Z

Zaffre. An oxide of cobalt, mixed with a portion of siliceous matter. It is imported in this state from Saxony.

Zero. The point from which the scale of a thermometer is graduated. The thermometer of Fahrenheit has its zero at that point at which it stands when immersed in a mixture of snow and common salt.

FINIS.